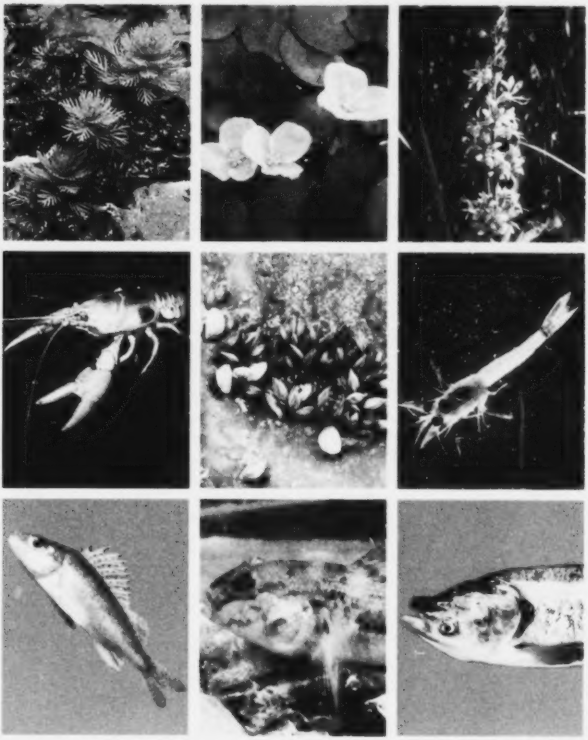
Ontario

Field Guide to Aquatic Invasive Species

Identification, collection and reporting of aquatic invasive species in Ontario waters



Algae

Plants

Invertebrates

Fishes

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Canada Ontario

1.0 INTRODUCTION

Invading species are recognized as a serious problem threatening global biodiversity and human health worldwide and are one of the leading causes of native species becoming rare, threatened or endangered. In the Great Lakes Basin alone, nearly 200 species from around the world have been introduced and include such well known species as the sea lamprey, zebra mussel, round goby, and purple loosestrife.

Once established, it can be extremely difficult and costly to attempt to eradicate introduced species, and control measures are usually very expensive and may be harmful to the environment. Preventing the introduction in the first place is the key to preventing long-term ecosystem harm. If prevention fails, it is critical to detect invading species upon initial introduction, collect a specimen for identification, and report the sighting immediately to the appropriate agency so that appropriate actions can be taken. For invading species already present and spreading, the same need and steps apply for tracking their spread.

The purpose of this field guide is to aid professionals in identifying aquatic invasive species (AIS), collecting specimens to confirm identification, and reporting AIS detected in Ontario waters. It is our hope that biologists, researchers, resource managers, field technicians, enforcement staff, and others who work in aquatic ecosystems and could encounter AIS will benefit from this guide. We ask for your assistance in reporting any occurrence of species new to Ontario or already present but in a new area to the Invading Species Hotline (1-800-563-7711) or website (www.invadingspecies.com), as described in section 3.0 REPORTING PROCEDURE.

A database of AIS sightings across the province is maintained through a partnership between the Ontario Ministry of Natural Resources (OMNR) and the Ontario Federation of Anglers and Hunters (OFAH), who have delivered the province-wide Invading Species Awareness Program since 1992. Information is shared with other jurisdictions and used to produce distribution maps, which are available through the hotline or website.

DEFINITIONS for alien and invading species in this field guide follow the Canadian Biodiversity Strategy (http://www.eman-rese.ca/eman/reports/publications/rt_biostrat/intro.html) and Invasive Alien Species Strategy and Action Plans for Canada (http://www.cbin.ec.gc.ca/issues/ias.cfm?lang=e) as follows:

Alien (introduced, non-native or exotic) species are species of plants, animals and micro-organisms introduced by human action outside their natural past or present distribution.

Invasive (or invading) species are those introduced species whose introduction or spread threatens the environment, the economy or society, including human health.

1.1 Using The Field Guide

The field guide is made with water-proof paper bound with rust-proof rings that can be opened and closed for removal or addition of pages. For example, the literature cited or other sections can be left out of the guide when taking it to the field, or new species pages can be inserted when they become available.

Organization of the field guide follows the process of identifying species, collecting information and specimens for verification, and reporting sightings. Identification of over 50 species covering algae, plants, invertebrates, and fishes is included. Each species can be found in the photo index on the back cover of the field guide.

1.1.1 Species identification

Within section 2.0 IDENTIFICATION, the species are grouped taxonomically and colour coded into algae (yellow), plants (green), invertebrates (brown), and fishes (blue). For each group (except algae), there is a glossary and illustration(s) of general morphology. Species within a group are ordered alphabetically by the first 3 letters of the family, genus and then species names as a way of numbering or ordering the pages: e.g., Ara-pis-str corresponds to *Pistia stratiotes* from the Araceae family. This way avoids complicating the order of pages in the future when new ones are added, i.e., they can be inserted alphabetically rather than by page number.

For each species, scientific and common names, photos, diagrams, and information under seven headings, as outlined below, are provided.

Description: the characteristics that can be used to identify the species; those included are usually visible externally and without a magnification lens.

Similar Species: species in Ontario that are similar in appearance to, or might be mistaken for, the species on that sheet; includes information on how to differentiate the species.

Habitat: a general description of the habitat in which the species could be found.

Introduced Range: the species' introduced range with emphasis on Ontario; includes presence in other provinces, general distribution in the United States, and introductions in other parts of the world. If more detailed information on Ontario distribution is needed, refer to www.invadingspecies.com or the literature cited. Information under this heading reflects distributions at the time of developing this guide, based on the most recent literature or database information available. It should be noted that AIS ranges continuously change as they continue to be introduced and spread.

Native Range: the continent or region of the world where the species is native.

Pathway of Introduction and Spread: the means through which a species can be transferred from one location to another by human-related activity (e.g., release of aquarium pets into waterways, transport of AIS between waterbodies via recreational boating, etc.). Note: natural means may also help spread these species but are not listed here (e.g., plankton and most aquatic plants can disperse via water currents).

Impacts: a general description of potential or documented impacts.

The information presented here is meant to help with species identification and detection, and as a general context for the species. It is not meant as a comprehensive literature review. Footnoted numbers in the text correspond to literature cited, found at the end of this guide.

1.1.2 Collecting specimens, recording information and reporting

Section 3.0 REPORTING PROCEDURE describes methods for collecting algae, plants, invertebrates, and fishes, what information to record and the process for submitting your information and specimen. To confirm a sighting, a specimen is needed for verification by experts (and might be retained in a collection as a voucher).

1.2 Additional Information

For more information on AIS, the Invading Species Awareness Program, or to request copies of the field guide and find out whether updated or new pages are available, call the Invading Species Hotline (1-800-563-7711), visit www.invadingspecies.com or email invading_species@ofah.org.

If you are interested in species-specific monitoring guidelines, you may also refer to the hotline/website/ email. Standard guidelines for volunteer monitoring of zebra mussel, spiny water flea, fanwort, rusty crayfish, red mysid, and round goby are available.

2.0 IDENTIFICATION

Algae

Plants

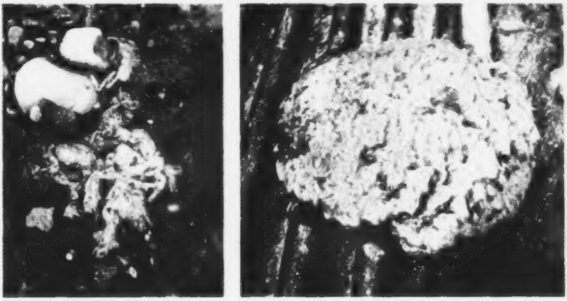
Invertebrates

Fishes

CYMBELLACEAE

Didymo

Didymosphenia geminata



Photos: Andrea Kirkwood

DESCRIPTION: Freshwater diatom, a type of single-celled algae, which produces mucilage and polysaccharide stalks that attach to rocks, plants or other submerged surfaces; individual diatoms can divide to form new diatoms and colonies. **Size:** individual cells are microscopic, but colonies of the diatom are visible to the naked eye; stalk produced is much longer in length than the cell itself(greater than 90% of visible biomass is stalk material). **Appearance:** stalks are brownish yellow to white in colour; colonies or mats of didymo may look like sewage sludge or wet tissue paper. **Texture:** appears slimy but to the touch it feels like wet cotton wool.[1,2,3]

SIMILAR SPECIES: Other stalked diatoms such as *Gomphonema* spp. can produce similar growth characteristics, but never reach bloom-levels like didymo, nor feel like wet-wool. Under the microscope, they are often an order-of-magnitude smaller than didymo cells, and possess only a single stigma (a type of cell opening) compared to 3-5 stigmata in didymo.[4]

HABITAT: Shallow waters of streams and rivers with high light exposure, in temperatures between 4-27°C, pH of 7 or above, and low nutrient but possibly nutrient-rich waters; attaches to rocks, vegetation or other substrates that are stable[1,2].

Cym-did-gem

INTRODUCED RANGE: Not known in Ontario, to date; in Canada, it has spread to Alberta and a first bloom in Québec occurred in 2006 in the Lower St. Lawrence region. It is also found in New Zealand.[1,5]

NATIVE RANGE: Possibly northern Europe, parts of Asia, and northern North America up to British Columbia (only) in Canada[1,2,5].

PATHWAY OF INTRODUCTION AND SPREAD: A single cell introduced to a waterbody can multiply to form new colonies. It can spread between waterbodies by attaching to boats, boat trailers and other equipment like fishing gear, diving equipment and waders, especially neoprene and felt-soled waders[1].

IMPACTS: Didymo algae blooms occur in streams and rivers, covering benthic substrate with up to 3 cm thick mats which can reach over 1 km in length. Massive blooms likely have a negative effect on community composition of benthic organisms of invertebrates and plants which use the same substrates for habitat. Mats can clog water intake pipes as well as foul water craft (e.g., boats) and equipment (e.g., fishing and scuba gear). Also, because the mats appear as sewage sludge or toilet paper along shorelines, there are concerns over aesthetics and water use in terms of tourism and recreational water usage. Swimmers have had eye irritations that might be associated with the diatom.[1,2,5]

ARACEAE / Arum Family

Water Lettuce

Pistia stratiotes

Other common name: None

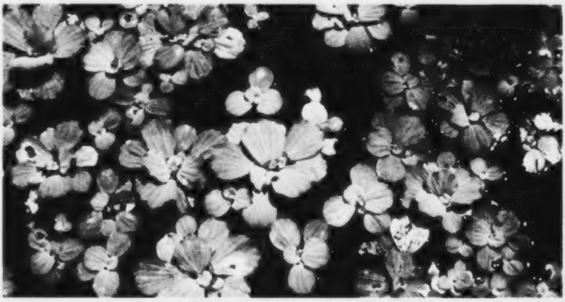


Photo: Ann Murray, University of Florida/IFAS Center for Aquatic and Invasive Plants

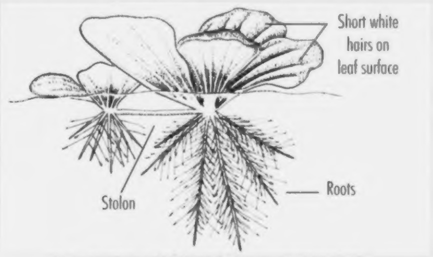


Illustration: University of Florida/IFAS Center for Aquatic and Invasive Plants

Photo: Richard Old

Description: Free-floating, perennial or annual aquatic plant. **Leaves:** floating, or nearly erect, several forming a rosette, without stems; blade simple, spongy, light green, having short white hairs, prominent nearly parallel ridges (veins), leaf rounded above and narrowed at the base, 2-20 cm in length. **Flowers:** inconspicuous, small, white to pale green, on small stalk from rosette; solitary female flower below and single whorl of male flowers above. **Fruit:** green berry, turning brown at maturity. **Stolons:** extend outward from plant to produce new plants (rosettes). **Roots:** submersed, numerous, hanging beneath rosette of leaves to 50 cm in length.[1]

SIMILAR SPECIES: None.

HABITAT: Slow moving waters, in streams, rivers, lakes, ponds, canals, and wet ditches[1]. Typically a plant of warmer climates but can act as an annual in colder environments, its seed overwintering and then germinating into new plants when temperatures warm[2].

INTRODUCED RANGE: In Ontario, ephemeral occurrences have been found in ponds connected to the Rideau Canal in Ottawa[3] and along the Welland River in Niagara Region in recent years[4]. In the United States, water lettuce is most abundant in the southeastern states but has been recorded for the Erie Canal in New York, Lake Erie in Ohio, and during 1997-2000 it occurred in Lake Winona in Minnesota[2,5]. It is also found throughout the tropics and subtropics[1].

NATIVE RANGE: Probably South America, Africa, and Asia[2,6,7].

PATHWAY OF INTRODUCTION AND SPREAD: Water lettuce first arrived in North America in the mid-1700's, likely through dumping of ship ballast water[7]. It is used as an ornamental plant of ponds and outdoor water gardens where it may intentionally be planted near or along shorelines and escape into new areas as plant material is discarded into a waterway and/or carried off by flooding during rain events. Water lettuce can spread between waterbodies via plant material, such as rosettes or seeds, transported with boats, boat trailers and other equipment (e.g., fishing or scuba gear).

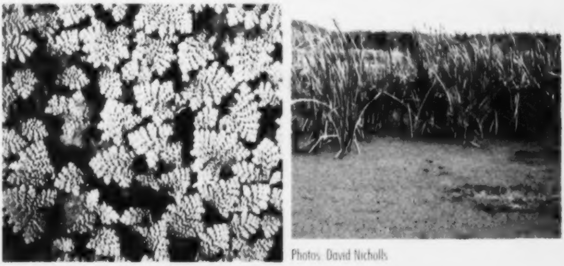
IMPACTS: Forms dense and large floating mats, restricting water flow in irrigation and flood control canals, and interfering with recreational activities (e.g., boating, fishing)[2]. The mats can also prevent sunlight penetration into water and reduce oxygen levels of water underneath, potentially effecting phytoplankton as well as fish communities[8].

AZOLLACEAE / Floating Fern Family

Mosquito Fern

Azolla pinnata

Other common names: Ferny azolla, pinnate mosquito fern



Photos: David Nicholls

DESCRIPTION*: Free-floating, annual aquatic fern. **Plants:** *A. pinnata* is green, sometimes red in colour, up to 2.5 x 2 cm in size, broadly triangular in shape, 2-pinnate branching, with secondary branchlets decreasing in length to base of main branch[1]. **Leaves:** minute and scale-like, alternate, overlapping, in 2 rows or 2-lobed, upper lobe green with minute hairs and in *A. pinnata*, ovate and 1-2 mm long[1,2]. **Stems:** branched, 1-5 cm, bearing roots[1,3]. **Roots:** to 5 cm long, with lateral rootlets in *A. pinnata*[1].

SIMILAR SPECIES: Watermosses (*Salvinia* spp: Sal-sal-spp in this guide), introduced to North America but not yet known from Canada, have larger (to 4 cm diameter), simple, rounded leaves compared to mosquito fern with leaves minute (1-2 mm), scale-like and overlapping, and the plant appearing triangular in shape[1,2,4,5]. Native duckweeds (*Spirodela polyrhiza*, *Lemna trisulca*, *Lemna minor*) have leaves that lack hairs and have short, unbranched roots compared to mosquito fern with minute upper leaf hairs and roots with lateral rootlets[2,6].

HABITAT: Quiet waters of ponds and lakes[1,2]. Shallow waters are ideal but *Azolla* also grows at greater depths. The plants cannot survive drought much longer than a few days. They may survive a wide temperature range from -5 to 35°C and a wide pH range of 3.5-10 depending on light intensity and temperature[7].

INTRODUCED RANGE: *A. pinnata* is not known from Ontario or Canada, to date. Found in Papua New Guinea, Australia, China, Japan, New Zealand, and Vietnam[8].

NATIVE RANGE: Asia and Africa[7].

PATHWAY OF INTRODUCTION AND SPREAD: The species is used as an ornamental plant of ponds and outdoor water gardens where it may intentionally be planted near or along shorelines and escape into new areas as plant material is discarded into a waterway and/or carried off by flooding during rain events. It may also be sold as an aquarium plant or arrive as contaminants in imports of other aquatic horticultural plants[9,10], and subsequently escape into the environment through dumping of aquarium contents into waterways. It can spread between waterbodies via plant fragments that are transported with boats, boat trailers and other equipment (e.g., fishing or scuba gear). This plant material can give rise to new plants and populations by multiplying vegetatively. In addition, because *Azolla* lives in symbiosis with blue-green alga enabling nitrogen fixation at substantial rates, it is applied in many parts of the world as a biofertilizer of agricultural crops such as rice and wheat[7], thereby representing another potential pathway for escape.

IMPACTS: Forms extensive growth, with red-coloured mats covering large surface areas of water[1]. It is capable of reducing light intensity as much as 90% as well as reducing photosynthesis and more than 50% of oxygen concentrations in water[7]. Altering habitat in these ways is likely to effect the growth of other plants in the water column requiring sunlight as well as other organisms reliant on oxygen and or submerged vegetation for shelter.

*Unless *A. pinnata* is specified, a general description of the family and its single genus, *Azolla*, is provided here because (1) Ontario contains only isolated and rare occurrences of the native *A. caroliniana* and no other *Azolla* spp.[11,12,13], (2) both *A. pinnata* and *A. caroliniana* are available through the horticultural trade representing a pathway of introduction[9,10], and (3) identifying *Azolla* specimens to species is complicated, typically requiring characteristics be viewed through an electron microscope[3,14], therefore, any plant found that is suspected of being a species in this family should be collected and reported as per section 3.0 REPORTING PROCEDURE in this guide.

BUTOMACEAE / Flowering Rush Family

Flowering Rush

Butomus umbellatus

Other common name: None

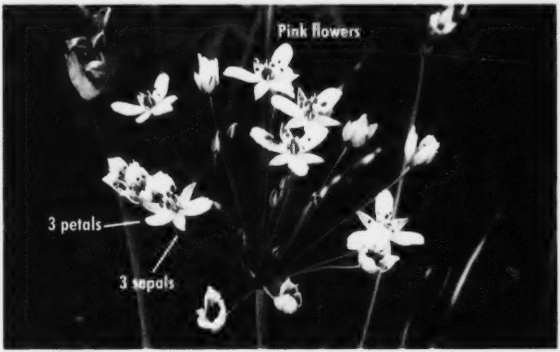


Photo: Wasyl Bakowsky

Photo: Nick Proulx

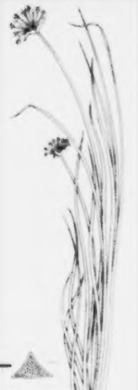


Illustration: University of Florida/IFAS Center for Aquatic and Invasive Plants

Description: Emergent, with submergent forms, perennial aquatic plant. **Leaves:** erect, floating or submersed, arising from a rhizome, not differentiated into blade and petiole, linear, up to 2.7 m long, 5-10 mm wide, parallel-veined, blade triangular in cross-section, tip usually spiraling[1,2]. **Flowers:** emergent, perfect, pink, 2-2.5 cm wide, pedicels 5-10 cm long; sepals 3, petals 3, stamens 9, pistils 6; numerous flowers per inflorescence, borne on an erect, leafless, flowering stalk to 1.5 m tall (or taller). Flowers during summer and fall[1,2]. **Fruit:** long-beaks, in a whorl[3]; may contain either hundreds of seeds if from population with fertile plants or no seed if from population of sterile plants[4]. **Bulbils:** pea-sized vegetative propagules borne on rhizomes and inflorescences, detach and disperse through water; can develop into new plant[5,6].

SIMILAR SPECIES: None. However, when flowers are absent, flowering rush superficially resembles some native bur-reeds (*Sparganium* spp.) except the leaves of flowering rush tend to spiral at leaf tips.

HABITAT: Shallow water, to 2 m deep in lakes, rivers, marshes, ponds, and wet ditches[2,3].

INTRODUCED RANGE: In Ontario, occurs throughout Lakes Erie, St. Clair and Ontario, as well as in western St. Lawrence River, Severn River and the Winnipeg River system[4,7,8]. Occurs in southern Québec and sparsely across the Canadian provinces as well as in northern United States[9].

NATIVE RANGE: Eurasia[2].

PATHWAY OF INTRODUCTION AND SPREAD: Flowering rush was first recorded in 1897 along the St. Lawrence River in Québec[10]. It is used as an ornamental plant of ponds and outdoor water gardens where it may intentionally be planted near or along shorelines and escape into new areas as plant material is discarded into a waterway and/or carried off by flooding during rain events. It can spread between waterbodies via dispersal of seeds, rhizome fragments and bulbils transported with boats, boat trailers and other equipment. Any of this plant material is capable of growing into a new plant[4,6,11].

IMPACTS: May displace native riparian vegetation and hinder recreational uses of water[12,13].

Fanwort

Cabomba caroliniana

Other common name: Cabomba

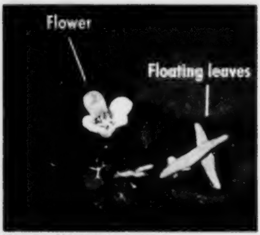


Photo: Donald A. Sutherland

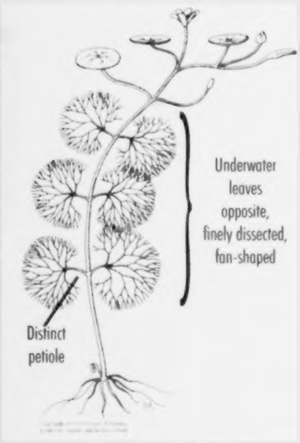

Underwater leaves opposite, finely dissected, fan-shaped
Distinct petiole

Illustration: University of Florida/IFAS Center for Aquatic and Invasive Plants

Photo: Sam Brinker

DESCRIPTION: Submerged, perennial, rooted aquatic plant. **Submersed leaves:** opposite or (rarely) whorled, on petioles to 15 mm in length; leaf blade palmately and finely dissected, fan-shaped, less than 6 cm broad[1,2]. **Floating leaves:** alternate, small, inconspicuous, on short to long petioles; leaf blade linear or oblong to 30 mm in length, margins entire; borne on flowering branches[2]. **Flowers:** usually emergent, occasionally submersed, small, 6-15 mm diameter on long flower stalk, borne singly; sepals 3, petals 3, white to pale yellow in colour and may include a pink or purplish tinge; stamens 3-6, pistils 2-4; yellow centre. Flowers between late spring and early fall[2]. **Main stem:** typically under 2 m and growing at water surface in Ontario, but reported up to 10 m tall elsewhere; branched, green-reddish in colour, white or reddish-brown hairs[3,4,5].

SIMILAR SPECIES: Bladderwort (*Utricularia vulgaris*), white water crowfoot (*Ranunculus aquatilis*), Northern water-milfoil (*M. sibiricum = exalbescens*), water marigold (*Megalodonta beckii*), coontail (*Ceratophyllum demersum*): however, only fanwort has the opposite, finely dissected, fan-shaped leaves on distinct petioles[1].

HABITAT: Rooted in silty substrate of stagnant to slow flowing waters in streams, small rivers, ponds, lakes, and ditches[4]. Occurs in permanent shallow water, usually less than 3 m but up to about 5 m deep in Ontario[3,5]. Prefers low pH (4-6) but may be found in alkaline waters[4]. The plant is able to overwinter and exist beneath heavy ice, retaining green leaves to spring[6].

INTRODUCED RANGE: In Ontario, the Crowe River watershed north of Peterborough is the only known occurrence in Canada, to date[7]. It is found in northeastern and southern United States, with occurrences in northwestern states[8]. Elsewhere, it occurs in India, Japan, Malaysia, and Australia[4,9].

NATIVE RANGE: Subtropic and temperate regions of South America[4].

PATHWAY OF INTRODUCTION AND SPREAD: The first report of fanwort in Ontario (and Canada) was in 1991[7]. The source of this introduction is not known but it is commonly sold as an aquarium plant and can escape into the environment through dumping of aquarium contents into waterways. Also, it can spread between waterbodies via plant fragments that attach to boats, boat trailers and other equipment (e.g., fishing or scuba gear). A fragment of stem with a pair of expanded leaves can grow into a new plant[10].

IMPACTS: Fanwort is extremely persistent. It can form dense stands, displacing native vegetation, clogging drainage canals and streams, and interfering with recreational uses like swimming and boating. The plant can significantly reduce water storage capacity and taint drinking water supplies.[5, 11]

CYPERACEAE / Sedge Family

European Lake Sedge

Carex acutiformis

Other common name: Lesser pond sedge

Photo: John Wilde

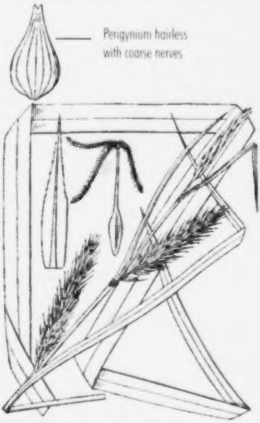


Illustration: From Britton, N.L. and A. Brown. 1913. Illustrated flora of the northern states and Canada. Vol. 1: 420.

DESCRIPTION: A large sedge, i.e., grass-like plant, often growing to 1 m in height or more. **Leaves:** plicate (M-shaped in cross-section), 5.5-15 mm in width. **Stems:** triangular in cross section. **Perigynium** (sac-like structure enclosing the 1-seeded fruit of *Carex*): hairless, coarsely 12- to 18- nerved (i.e., having simple but obvious veins) and 3-4.5 mm in length[1]. Fruiting in this species occurs between June and August[2].

SIMILAR SPECIES: Sedges differ from grasses in that they have triangular stems in cross section, as opposed to grasses which have round stems. While sedges are in general a difficult group of plants to identify, *C. acutiformis* can be distinguished from other similar large wetland sedge species by the combination of plicate leaves (M-shaped in cross-section vs. V-shaped in other species) 5.5-15 mm in width and perigynium that is hairless, coarsely 12- to 18- nerved and 3-4.5 mm in length[1]. Further, the leaves of this plant remain green longer into the fall and after frost than many native sedges.[1]

HABITAT: Wide range of wetlands such as swamps and marshes, as well as wet open thickets, sedge meadows and lakeshores[2]. In Ontario, it is found in swamp with permanent water up to 50 cm deep as well as in some adjacent drier areas[3].

INTRODUCED RANGE: In Ontario, the species is present in Stony Swamp, near Ottawa, which is the only known occurrence in Canada, to date[1]. It is present in six states in the northeastern United States[2].

NATIVE RANGE: Eurasia and Africa[2].

PATHWAY OF INTRODUCTION AND SPREAD: European lake sedge was first collected in Ontario near Ottawa in 1987. It is suspected that the plant was introduced to the Ottawa area through hay from Europe. There are concerns that it may spread from roadside ditches where it occurs. The seeds, rhizome and root masses of the plant may attach to animals or possibly road maintenance equipment/vehicles passing through a stand of this plant.[1]

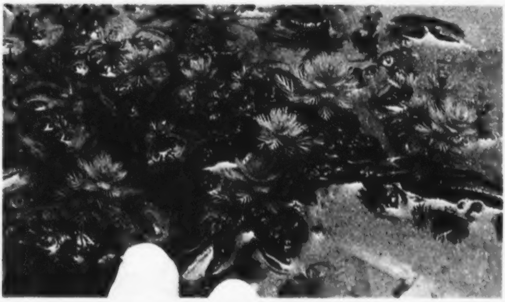
IMPACTS: European lake sedge is able to dominate habitat area. The plant's dense leaf growth and extensive rhizome development enable it to effectively expand, compete for light and suppress other species.[1]

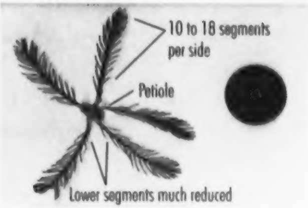
HALORAGACEAE / Water-Milfoil Family

Parrotfeather

Myriophyllum aquaticum

Other common names: Brazilian watermilfoil, water-feather





Photos: Peter W. Bergstrom, National Oceanic and Atmospheric Administration/ Department of Commerce.

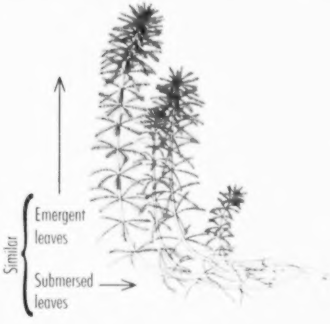


Illustration: University of Florida/IFAS Center for Aquatic and Invasive Plants

Description: Submerged, perennial aquatic plant. **Leaves:** whorled, bright green in colour, feather-like, pinnately divided with 10-18 thread-like segments along each side, the lower segments much reduced, petiole 5-7 mm; emergent and submersed leaves alike, emergent leaves usually 2.5-3.5 cm long with segments 4-8 mm long[1,2,3]. **Flowers:** inconspicuous, in axils of emergent leaves (or bracts), forming terminal spike above water; uppermost flowers opposite or whorled; male and female flowers on different plants; only female, white flowers are known to occur in North America. Flowering occurs in spring and sometimes fall.[1,3,4]

SIMILAR SPECIES: Introduced Eurasian water-milfoil (*M. spicatum*: Hal-myr-spi in this guide) lacks leaf petioles or has petioles <2 mm and pink flowers compared to parrotfeather with distinct petioles and white flowers[3]. Native Northern water-milfoil (*M. sibiricum = exalbescens*) has leaves with 11 or fewer segments on each side of axis, not 10-18 as in parrotfeather. Additionally, the emergent leaves that are conspicuous and similar to submersed leaves in parrotfeather distinguish the species from other *Myriophyllum* species. Native coontails (C*eratophyllum demersum, C. echinatum)* have leaves that are dichotomously divided rather than pinnately as in parrotfeather.[2]

HABITAT: Shallow waters of ponds, lakes, streams and ditches[2].

INTRODUCED RANGE: In Ontario, parrotfeather previously occurred in isolated ponds in Midhurst but was eradicated in 2006[5]. It is found in the Fraser Valley of British Columbia, numerous states in the United States and in Africa, Australia, Europe, Indonesia, Mediterranean, New Zealand, and South Africa[6,7,8].

NATIVE RANGE: South America[1].

PATHWAY OF INTRODUCTION AND SPREAD: Because it is commonly sold as an aquarium plant, parrotfeather can escape into the environment through dumping of aquarium contents into waterways. It can spread between waterbodies via plant fragments that attach to boats, boat trailers and other equipment (e.g., fishing or scuba gear), and which can give rise to new plants.

IMPACTS: Forms dense stands over large areas, shading out other organisms, interfering with irrigation and drainage canals, and restricting recreational activities[4].

HALORAGACEAE / Water-Milfoil Family

Eurasian Water-Milfoil

Myriophyllum spicatum

Other common name: None

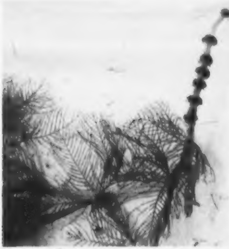


Photo: Iowa Department of Natural Resources

Photo: John Hardy, University of Wisconsin - Stevens Point Department of Biology

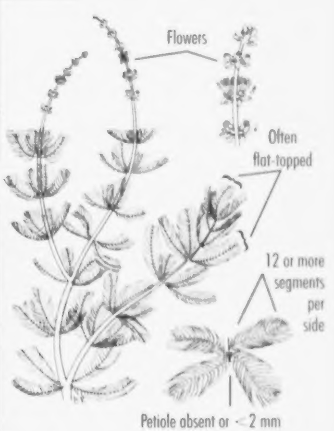


Illustration: University of Florida/IFAS Center for Aquatic and Invasive Plants

DESCRIPTION: Submerged, perennial aquatic plant. **Leaves:** whorled, feather-like, pinnately divided with 12 or more thread-like segments along each side, petiole absent or less than 2 mm[1,2]. **Flowers:** emergent, on terminal spike above water, about 5-20 cm long, upper flowers male and lower flowers female, pink, in 3-10 whorls; bracts usually equal to twice (but no more) the length of female flowers. Flowers between late July and early August.[3] **Stem:** leafy shoot, 0.5-7 m long, branching especially at water surface; tips usually reddish, stem below the inflorescence thicker to almost double the width of the lower stem, usually curved to lie parallel with the water surface[1,2,3].

SIMILAR SPECIES: Parrotfeather (*M. aquaticum*: Hal-myr-aqu in this guide), introduced to North America but not currently in Ontario, can be distinguished from other

Myriophyllum spp. by its emergent and submersed leaves which are similar[1]; parrotfeather also has longer petioles and white flowers compared to Eurasian water-milfoil with petioles absent or <2 mm and pink flowers[2]. Native Northern water-milfoil (*M. sibiricum = exalbescens*) has leaves with 11 or fewer segments on each side of axis, forms turions and the stem below the inflorescence is same in width as the lower stem compared to Eurasian water-milfoil where it is thicker to twice the width, turions are not formed and leaves have 12 or more segments per side. In addition, knob-like, shoot tips of crowded leaves are diagnostic of Northern water-milfoil but not always present. Native coontails (C*eratophyllum demersum, C. echinatum)* have leaves that are dichotomously divided rather than pinnately as in Eurasian water-milfoil.[1,3,4]

HABITAT: Most common in 1-3 m deep water of lakes, rivers and ponds, but can occur at depths up to 10 m. It can be found in alkaline or acid waters. It flourishes in high nutrient environments but also can be found in nutrient poor waters.[1,3]

INTRODUCED RANGE: In Ontario, it occurs in the Great Lakes and southern Ontario, to coastal Georgian Bay on the southern Canadian Shield[2,5,6]. It is also found in southwestern Québec, the St. Lawrence River system, British Columbia, and throughout much of the United States[2,7].

NATIVE RANGE: Eurasia[1].

PATHWAY OF INTRODUCTION AND SPREAD: The species was introduced to North America in the late 19th century and first recorded in Canada from Lake Erie in 1961. Initial introductions may have been from shipping ballast or aquarium release. It can spread between waterbodies via plant material that attaches to boats, boat trailers and other equipment (e.g., fishing or scuba gear), and which can give rise to new plants.[3]

IMPACTS: Forms dense stands with entangled branches near water surface over large areas, suppressing native vegetation and impeding water traffic and recreation[3,8,9]. The plant may hybridize with native milfoils and possibly create more vigorous or aggressive forms of the invasive plant[10].

HYDROCHARITACEAE / Frog-Bit Family

Brazilian Waterweed

Egeria densa

Other common names: Brazilian Elodea, waterweed

Photo: Ann Murray, University of Florida/IFAS Center for Aquatic and Invasive Plants

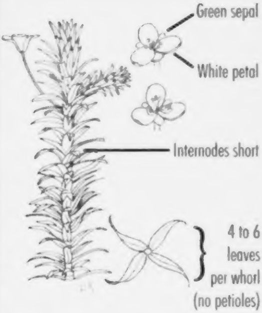


Illustration: University of Florida/IFAS Center for Aquatic and Invasive Plants

DESCRIPTION: Submerged, perennial, rooted aquatic plant. **Leaves:** submersed, lowest leaves opposite or whorls of 3, smaller in size than middle and upper leaves in whorls of 4 to 6 and 12-40 mm long by 1.7-5 mm wide; attached to stem without a petiole; leaf margins minutely toothed requiring a hand lens to view; internodes short[1,2]. **Flowers:** emergent, producing nectar, extend to surface by slender stalk, male and female flowers on separate plants; 3 green sepals, 3 white petals 4-11 mm in length, petals much longer than sepals. Flowers during summer and fall.[1,2,3] **Stems:** erect, rooted in substrate, branched or unbranched, 1-3 mm diameter, up to 2 m in length[1,3,4].

SIMILAR SPECIES: Resembles native waterweeds (*Elodea canadensis, E. nuttallii*) but leaves are shorter and opposite or 3 in a whorl, flowers lack nectaries, and petals are about the same size as sepals, compared to Brazilian waterweed with main leaves 4-6 in a whorl, flowers with nectaries, and petals much longer than sepals[1]. Aquarium plants Hydrilla (*Hydrilla verticillata*: Hyd-hyd-ver in this guide), introduced to North America but not yet Canada, and narrow leaf anacharis (*Egeria najas*), not introduced, have leaf margins distinctly toothed which can be seen with the naked eye compared to the minutely toothed leaf margins of Brazilian waterweed (which require magnification to view). Additionally, Hydrilla has prickles on its lower leaf surface and fringed stipules with orange-brown hairs while the other species do not[5]. Hydrilla also lacks nectaries and has petals and sepals about the same in size[1].

HABITAT: Shallow waters of lakes, streams, ponds, and ditches[3,6]. It is more common in warm-temperate and cool subtropical conditions but is capable of surviving winter[1,4].

INTRODUCED RANGE: Not known from Ontario, to date; in Canada, it is reported from southwestern British Columbia[1]. Found in many states in the United States, central America, South Africa, Australia, Europe, and Japan[4].

NATIVE RANGE: South America[4].

PATHWAY OF INTRODUCTION AND SPREAD: The species was introduced to North America in the late 19th century and first recorded in Canada from Vancouver Island in 1974[1,7]. It is commonly sold as an aquarium plant and also is widely used in teaching botany classes and plant research (because of its cellular structure), where it may subsequently escape into the environment through dumping of aquarium contents into waterways[1,3,7]. It can spread between waterbodies via plant fragments that attach to boats, boat trailers and other equipment (e.g., fishing or scuba gear), and which can give rise to new plants.

IMPACTS: Forms dense monoculture stands over very large areas, restricting water movement, trapping sediment, and interfering with recreational uses, e.g., boating, fishing, swimming, and water skiing[7].

HYDROCHARITACEAE / Frog-Bit Family

European Frog-Bit

Hydrocharis morsus-ranae

Other common name: Common frog-bit

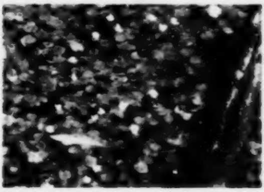


Photo: Michigan Sea Grant, www.miseagrant.umich.edu

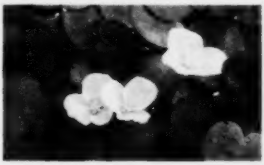


Photo: Wasyl Bakowsky

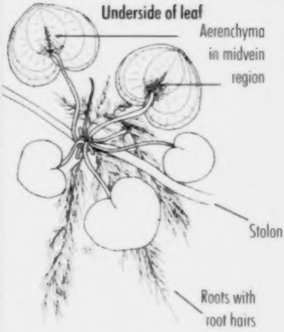


Illustration: University of Florida/IFAS Center for Aquatic and Invasive Plants

DESCRIPTION: Free-floating, or rooted when on mud, perennial aquatic plant. **Leaves:** floating, forming a rosette; differentiated into blade and petiole, blade round or heart-shaped, up to about 6 cm wide, aerenchyma on underside of leaf in midvein region (not margin to margin); two lateral stipules (appendages) up to 2.5 cm long and free from the leaf petiole base[1,2,3]. **Flowers:** emergent, male and female flowers on different plants; 3 green sepals; 3 white to pinkish petals, up to about 2 cm and 2-3 times the length of the sepals; male flowers 1-5 per inflorescence, pedicel to 4 cm, stamens 9-12; female flowers solitary, pedicel to 9 cm, styles 6. Flowers between spring and fall.[1,3,4] **Fruits:** spherical, many-seeded berry[1,5]. **Stolons:** lateral, below water surface or soft mud, produces terminal buds which develop a single root and give rise to new rosettes[2]. **Turions:** modified stolon buds about 1 cm long, detach and overwinter on lake floor, then surface in spring to form new plants[2]. **Roots:** unbranched, up to 50 cm long, with numerous root hairs[1,3].

SIMILAR SPECIES: North American frog-bit (*Limnobium spongia*) has aerenchyma on lower leaf surface from margin to margin, a single stipule from leaf petiole base, and flower petals under 1.5 times the length of sepals compared to European frog-bit with aerenchyma confined to the midvein region, stipules in pairs, and petals 2 to 3 times the length of sepals[1,2]. Native water-shield (*Brasenia schreberi*) has mucilaginous coating under water, stems arising from creeping rhizome, leaves not forming a rosette, and purplish flowers while European frog-bit has white to pinkish flowers, leaves forming a rosette and no mucilaginous coating[4,6].

HABITAT: Generally in areas with limited wave action, slow moving water, sheltered inlets, ponds, rivers, and ditches[3,7].

INTRODUCED RANGE: In Ontario, the plant occurs in the St. Lawrence River to Lake Ontario, through the Kawartha Lakes, the Rideau and Ottawa Rivers systems, and some other inland waterbodies, with occurrences along Lakes Erie and St. Clair[3,8,9]. It is also spreading northward with numerous occurrences scattered at sites throughout the southern margin of the Canadian Shield[10]. It is found across southwestern Québec and the St. Lawrence River, and in New York and Vermont[5,8].

NATIVE RANGE: Eurasia[1].

PATHWAY OF INTRODUCTION AND SPREAD: European frog-bit was originally introduced to an arboretum at the Central Experimental Farm in Ottawa in 1932, and then observed in the adjacent Rideau Canal in 1939[11]. The plant can spread between waterbodies via dispersal of seeds, plant fragments and turions that are transported with boats, boat trailers and other equipment (e.g., fishing or scuba gear). Turions and fragments of stem with stolon buds are capable of growing into new plants[3].

IMPACTS: Forms large, dense, floating mats of intertwining plants, reducing native submerged plant cover by diminishing light and competing for gases and nutrients; European frog-bit also impedes water flow and traffic, and recreational activities[3,7,8].

HYDROCHARITACEAE / Frog-Bit Family

Hydrilla

Hydrilla verticillata

Other common names: Water thyme, water weed, Florida elodea

Photo: Vic Ramey, University of Florida/IFAS Center for Aquatic and Invasive Plants

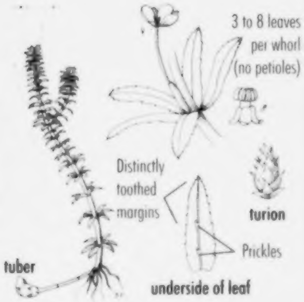

3 to 8 leaves per whorl (no petioles)
Distinctly toothed margins
turion
Prickles
tuber
underside of leaf

Illustration: University of Florida/IFAS Center for Aquatic and Invasive Plants

Photo: Maryland Department of Natural Resources

DESCRIPTION: Submerged, perennial, rooted aquatic plant. **Leaves:** submersed, 3-8 in a whorl, attached to stem without petioles; blade linear, 8-20 mm long, 1.2-4 mm wide; margins with prominent, sharp teeth and sometimes prickles on midvein of lower leaf surface readily seen with naked eye; stipules in leaf axis fringed with orange-brown hairs; internode as long as the leaves and up to 50 mm long[1,2,3]. **Flowers:** small, male and female flowers on separate or same plants, petals 3, sepals 3; male flowers short stalked, solitary or in pairs in leaf axils, petals and sepals about 2-3 mm long and whitish to reddish in colour, released underwater as buds, floating to water surface to open; female flowers with petals and sepals up to 4 mm long, white or light green with red streaks, extend to water surface on slender stalk to 10 cm in length. Flowers during summer and fall.[2,4,5,6] **Stems:** erect, rooted in substrate, branched or unbranched, elongate, bearing turions[2]. **Turions:** those from rhizomes are brownish with a smooth surface; those from erect stems are green and with scales[2].

SIMILAR SPECIES: Resembles native waterweeds (*Elodea canadensis, E. nuttallii*) and introduced Brazilian waterweed (*Egeria densa*: Hyd-ege-den in this guide), except Hydrilla has distinctly toothed leaf margins readily seen with naked eye. Presence of prickles on lower leaf surface and fringed stipules with orange-brown hairs also distinguish Hydrilla from these species as well as narrow leaf anacharis (*Egeria najas*) which is not known from North America but imported through the aquarium trade.[3]

HABITAT: Rivers, lakes, ponds, streams, and wet ditches, in shallow waters up to about 50 cm deep but also at depths over 7 m[1,4,5,6].

INTRODUCED RANGE: Not known from Ontario or Canada, to date[7]. Present in the United States but largely absent from the central states[8]. Found on every continent except Antarctica[9].

NATIVE RANGE: Asia[4].

PATHWAY OF INTRODUCTION AND SPREAD: Hydrilla is available as an aquarium plant and may escape into the environment through dumping of aquarium contents into waterways. It can spread between waterbodies via plant fragments and turions that attach to boats, boat trailers and other equipment (e.g., fishing or scuba gear). A fragment of stem as well as turions are able to grow into new plants[4].

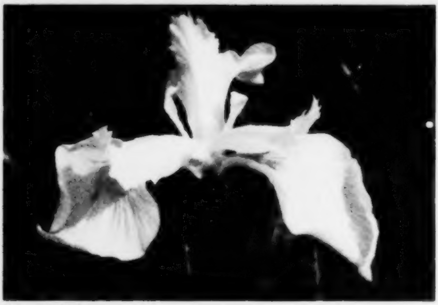
IMPACTS: Forms tall and dense stands in the water column, potentially displacing other aquatic organisms, impeding water flow, boating traffic, swimming, fishing, and other recreational activities as well as clogging irrigation pump filters[5,9].

IRIDACEAE / Iris Family

Yellow Iris

Iris pseudacorus

Other common name: Yellow flag



Photos: Wasyl Bakowsky

DESCRIPTION: Emergent, perennial aquatic plant. **Leaves:** erect, simple, linear, sword-shaped, 40-100 cm by 2-3 cm, parallel-veined, arising from rhizomes[1,2]. **Flowers:** bright yellow, 7-9 cm wide; sepals 3, spreading, with brown markings, 5–7.5 cm by 3–4 cm, much larger than petals; petals 3, erect, 2-3 cm; 4-12 flowered-inflorescence. Flowers between April and July.[1,2,3] **Fruit:** capsule, 3- or 6-angled, 3.5-8.5 cm, beaked[1,2]. **Stems:** solid, 70-150 cm tall[2]. **Rhizomes:** pink, freely branching, 1-4 cm diameter, with remains of old leaves. **Roots:** fleshy, about 10-30 cm long.[2,4]

SIMILAR SPECIES: In North America, iris plants with flowers entirely yellow belong only to *I. pseudacorus.* When only leafy material is present and flowers are absent, yellow iris resembles native blue flag (*I. versicolor*), which often is purplish in colour around the leaf base, and has shorter stems (20-60 cm) and typically smaller leaves (10-80 cm by 1-3 cm) than yellow iris.[2]

HABITAT: Wetlands, and shallow water along streams, rivers, ponds, and lakes[1,5].

INTRODUCED RANGE: Occurrences through southern Ontario and parts of southern Canada[3,6,7]. It is widespread through most of the United States[8].

NATIVE RANGE: Eurasia[5].

PATHWAY OF INTRODUCTION AND SPREAD: Likely introduced as an ornamental garden plant, the earliest record of yellow iris occurring in Canada was from Newfoundland in 1911; by 1940, it was observed in Ontario[3]. It is used as an ornamental plant of ponds and outdoor water gardens where it may intentionally be planted near or along shorelines and escape into new areas as plant material is discarded into a waterway and/or carried off by flooding during rain events. It can spread between waterbodies via rhizome fragments and possibly fruit or seed that are transported with boats, boat trailers and other equipment (e.g., fishing or scuba gear).

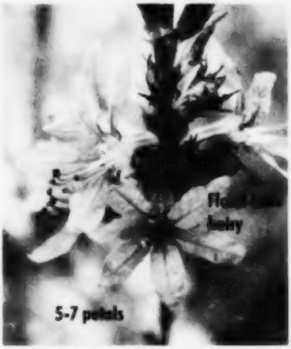
IMPACTS: Yellow iris can form dense stands, particularly with very thick rhizome mats; it may displace native vegetation and convert habitat from a wet to drier environment[9]. The plant causes poisoning in animals if rhizomes are ingested or plant juices make skin contact; in humans, general symptoms of poisoning include blistering[10].

LYTHRACEAE / Loosestrife Family

Purple Loosestrife

Lythrum salicaria

Other common name: Spike loosestrife



Photos: Dave Britton

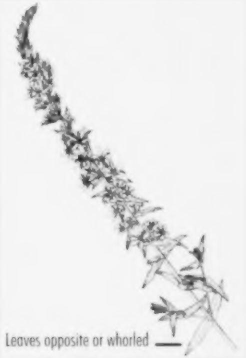


Illustration: University of Florida/IFAS Center for Aquatic and Invasive Plants

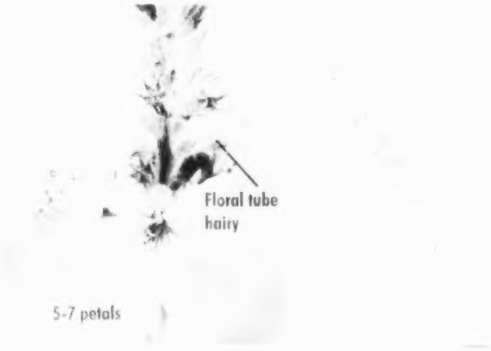
DESCRIPTION: Emergent, perennial wetland plant. **Leaves**: opposite or whorled, 3-10 cm long, without petiole, lance-shaped to egg-shaped[1,2]. **Flowers:** in axillary clusters of 2 or more, forming terminal spike-like inflorescence; floral tube hairy; petals 5-7, pink-purple in colour, 5-12.5 mm long, stamens 10-14. Flowering occurs from July to October[1,2,3]. **Stem:** erect, hairy or not, angular or squarish; reaches over 2 m tall; numerous stems arising from a common rootstock[1,4,5].

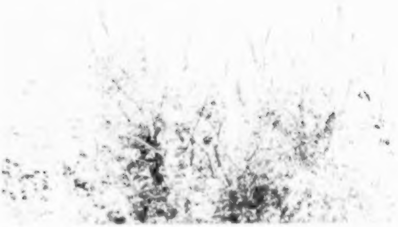
SIMILAR SPECIES: Native winged loosestrife (*Lythrum alatum*), a much smaller plant, has alternate leaves on upper

Purple Loosestrife

Lythrum salicaria

Other common name: Spike loosestrife





Description: Emergent, perennial wetland plant. **Leaves:** opposite or whorled, 3-10 cm long, without petiole, lance-shaped to egg-shaped. **Flowers:** in axillary clusters of 2 or more, forming terminal spike-like inflorescence; floral tube hairy; petals 5-7, pink-purple in colour, 8-12.5 mm long; stamens 10-14. Flowering occurs from July to October. **Stem:** erect, hairy or hairless, 4-sided (square), reaches over 2 m tall; numerous stems arise from a common rootstock.

Similar Species: Narrow-winged loosestrife (*L. alatum*), a much smaller plant, has alternate leaves on upper stem with small, solitary flowers in leaf axils and floral tubes without hair compared to purple loosestrife which has floral tubes with hair and flowers located terminally (at the ends of stalks) in clusters in the axils of opposite/whorled leaves[1,2,3]. Pickerel-weed (*Pontederia cordata*) has leaves which are basal, long-petioled and heart-shaped compared to opposite/whorled, without a petiole and lance- to egg-shaped, in purple loosestrife[1,2,4]. Swamp loosestrife (*Decodon verticillatus*) leaves are short-petioled, flowers do not form a terminal spike, and its stem is arching and rooting at tips[2].

HABITAT: Marshes, floodplains, river and stream margins, wet ditches and fields[2,3].

INTRODUCED RANGE: In Ontario, it is abundant throughout the St. Lawrence River and Great Lakes basin[1]; occurrences are scattered further north, in the vicinity of towns including Timmins, Geraldton and Sioux Lookout[6]; scattered occurences on the Rainy River clay plain in western Ontario[7]. Present in all other provinces and, in the United States, it is present in most states[1,8].

NATIVE RANGE: Eurasia[4].

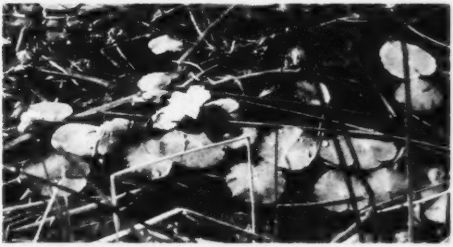
PATHWAY OF INTRODUCTION AND SPREAD: Purple loosestrife arrived in Canada in the early 19th century: possible sources include unloading of solid ship ballast containing seed, imported wool or sheep with attached seeds, or deliberate introductions for medicinal purposes or as a nectar and pollen source in beekeeping[1]. It is also used as an ornamental plant of ponds and outdoor water gardens where it may intentionally be planted near or along shorelines and escape into new areas as plant material is discarded into a waterway and/or carried off by flooding during rain events. It can spread between waterbodies via plant material such as root buds or tiny seeds which can attach to, and be transported with, boats, boat trailers and other equipment (e.g., fishing or scuba gear).

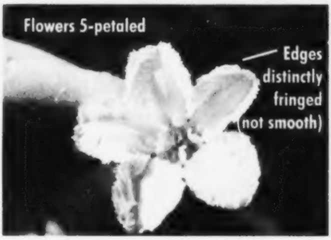
IMPACTS: Forms dense monocultural stands over very large areas, threatening wetland habitat and communities, potentially affecting decomposition rates and nutrient cycling, and reducing or displacing (directly or indirectly) native species of plants, birds and invertebrates[5,9,10].

Yellow Floating Heart

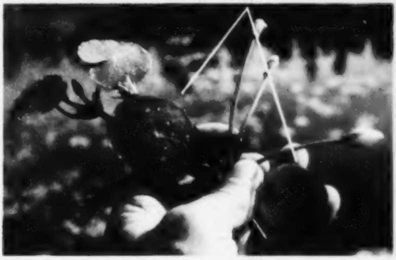
Nymphoides peltata

Other common names: Fringed water lily, floating heart





Photos: Fred Hrusa



DESCRIPTION: Floating, perennial, rooted aquatic plant. **Leaves:** floating, simple, heart-shaped to almost circular, 3-10 cm broad, with long leaf stalk arising from underwater rhizomes; short-petioled leaves occur as a pair of opposite leaves and with yellow flowers just above[1,2]. **Flowers:** occur at water surface, bright yellow in colour, 2-4 cm in diameter; 5-petaled with edges distinctly fringed. Flowers between June and October.[3,4] **Fruit:** strongly beaked, 12-25 mm[2].

SIMILAR SPECIES: The bright yellow flowers with the pair of opposite leaves in this species distinguish it from other *Nymphoides* spp. in northeastern North America[2]. Superficially, it is similar to native yellow pond and bullhead lilies (*Nuphar variegatum, N. advena)* which have yellow flowers but lack the fringed petal edges of yellow floating heart.

HABITAT: Prefers quiet waters, slow moving rivers, lakes, ponds, and canals; it can grow on damp mud and water to 4 m deep[1,3].

INTRODUCED RANGE: In Ontario, the only known location of yellow floating heart is Ottawa, in ponds connected to the Rideau Canal[5,6]. It is found in Québec[7] and recently in Dartmouth, Nova Scotia[8]. It also occurs in several states in the United States[7], and in New Zealand[9].

NATIVE RANGE: Southern Europe and Asia[4].

PATHWAY OF INTRODUCTION AND SPREAD: Yellow floating heart was first introduced to the United States in the late 19th century, likely as an ornamental garden plant[4]. It is still used as an ornamental plant of ponds and outdoor water gardens where it may intentionally be planted near or along shorelines and escape to new areas as plant material is discarded into a waterway and/or carried off by flooding during rain events. It can spread between waterbodies via plant fragments and possibly fruit or seed that are transported with boats, boat trailers and other equipment (e.g., fishing or scuba gear).

IMPACTS: Grows in dense patches, forming floating mats that can exclude native species, create stagnant water with low oxygen levels beneath mats, and interfere with recreational activities such as fishing, boating, and swimming[1].

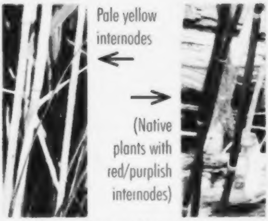
POACEAE / Grass Family

European Common Reed

Phragmites australis subsp. *australis*

Other common names: Phragmites, common reed, common reed grass, giant reed

Photo: Michigan Sea Grant, www.miseagrant.umich.edu



Photos: Wasyl Bakowsky

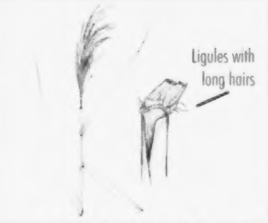


Illustration: University of Florida/IFAS Center for Aquatic and Invasive Plants

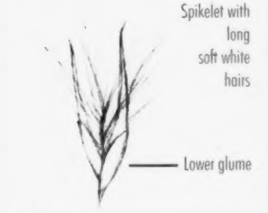

Spikelet with long soft white hairs
Lower glume

Illustration: Jessica da Silva

DESCRIPTION: Extremely tall, emergent, perennial grass growing in dense stands. **Leaves:** alternate, flat, elongate, gradually tapering to a point, 15-40 cm long, 2-4 cm wide[1,2]. **Ligules:** about 1 mm, somewhat translucent, thin, fraying into short matted hairs; longer hairs at the collar[2,3]. **Stem (culm):** erect, hollow, 1-4 m tall, 0.5-1.5 cm thick, from rhizome; internodes at culm base a pale yellow in summer to late fall[1,2,4,5]. **Inflorescence:** terminal, dense, large, 5-35 cm long, 8-20 cm wide, many-branched with spikelets of 3-10 flowers; long soft white hairs give a feathery appearance to inflorescence; glumes (or bracts) smooth, lower glume of spikelet 2.6-4.2 mm long[1,2,5]. Flowers in late summer and early fall[6].

SIMILAR SPECIES: Native subspecies *P. australis* subsp. *americanus* has red or purplish internodes at the base of the plant and a longer lower glume, 3.8-7 mm, compared to a 2.6-4.2 mm glume and yellow basal internodes in subsp. *australis* [5]. Native wild-rice (*Zizania* spp.) lacks the feathery-appearing inflorescence and has 1-flowered spikelets with no glumes compared to phragmites with feathery inflorescence, glumes present and many-flowered spikelets[3]. Ornamental plume-grass (*Miscanthus* spp.) is another introduced, tall perennial grass but its leaf blades are sharply toothed unlike phragmites[3]. Ornamental giant reed (*Arundo donax*) grows to 10 m, much taller than phragmites, and has glumes with soft whitish hairs, 6-8 mm long, while phragmites glumes are hairless[2,6].

HABITAT: Wide range, in shallow waters of brackish as well as freshwater wetlands, streambanks, lakeshores, wet fields and ditches[7,8,9,10].

INTRODUCED RANGE: Southern Ontario, with scattered occurrences as far north as Georgian Bay and Lake Superior[11]. Common throughout southern Québec, and present in Alberta, New Brunswick and Nova Scotia[11,12]. Found throughout much of the United States[13,14].

NATIVE RANGE: Eurasia[13,14].

PATHWAY OF INTRODUCTION AND SPREAD: The species was probably introduced by dumping of solid ship ballast, which contained the plant, along the Atlantic Coast in the early 19th century[13]. In more recent times, phragmites has been planted for wetland rehabilitation and stabilization[15], and may be sold through the horticultural trade as an ornamental plant: because the native and introduced subspecies are very similar and were only recently recognized as distinct from one another, the introduced type may also be available commercially. Consequently, *P. australis* subsp. *australis* may be planted near or along shorelines and escape into new areas as plant material is discarded into a waterway and/or carried off by flooding during rain events. It can spread between waterbodies via dispersal of seeds and rhizome or stolon fragments transported with boats, boat trailers and other equipment.

IMPACTS: Forms large monocultural stands, displacing native wetland vegetation, reducing plant species richness, and threatening habitat of rare species, species at risk and other wetland species[7,8,9,10,14,16,17].

PONTEDERIACEAE / Pickerel-Weed Family

Water Hyacinth

Eichhornia crassipes

Other common name: None

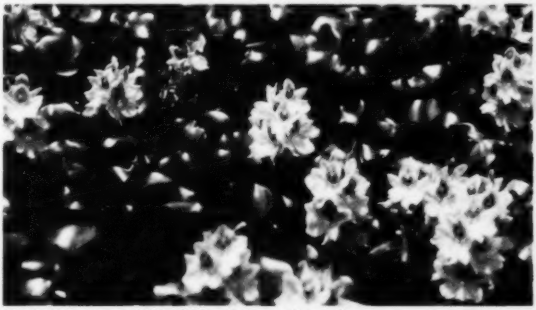
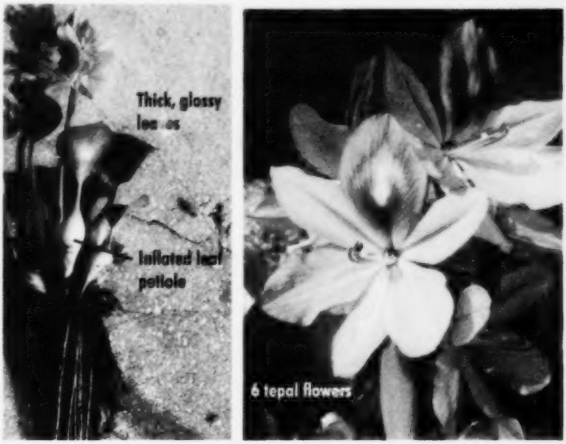


Photo: Vic Ramey, University of Florida/IFAS Center for Aquatic and Invasive Plants



Photos (bottom): Richard Old

DESCRIPTION: Free-floating, perennial aquatic plant. **Leaves:** floating or emergent, forming a rosette; blade thick, glossy, egg-shaped to round, up to 11 x 9.5 cm in size; petiole 3.5-33 cm, usually swollen (inflated); stipule 2.5-14 cm[1,2]. **Flowers:** emergent, showy, violet-blue colour, one tepal with darkened middle area and yellow spot within; tepals 6, 16-37 mm, margins entire; stamens 6, up to 35 mm in length; 4-15 flowers per inflorescence[2,3].

Flowers between early spring and late fall[2]. **Stolons:** extend outward from plant to produce new plants (rosettes) which readily break apart from one another[1,4]. **Roots:** submersed, numerous, hanging beneath rosette[1].

SIMILAR SPECIES: None.

HABITAT: Ponds, rivers, canals and wet ditches, particularly in nutrient rich waters; survives large fluctuations in water levels[3,4].

INTRODUCED RANGE: Not currently known from Ontario; however, in 2004 only, two plants were found at Buckhorn Lake, which is one of the Kawartha Lakes in Peterborough County (it is not believed to have persisted there)[5]. Occurs in the United States, but largely absent from the central states[6]. Found in Asia, Africa, India, and Australia[7].

NATIVE RANGE: South America[4].

PATHWAY OF INTRODUCTION AND SPREAD: It is used as an ornamental plant of ponds and outdoor water gardens where it may intentionally be planted near or along shorelines and escape into new areas as plant material is discarded into a waterway and/or carried off by flooding during rain events. It can spread between water bodies via plant material such as rosettes or seeds that are transported with boats, boat trailers and other equipment (e.g., fishing or scuba gear).

IMPACTS: In other parts of the world, water hyacinth grows and spreads rapidly over very large areas in a short time period forming continuous, dense floating mats sometimes up to 2 m thick; oxygen levels in the water are reduced under mats, native species are displaced, water flow and traffic are impeded, irrigation canals are blocked, and hydroelectric and water treatment plants are hindered as are recreational activities like fishing[4,8].

POTAMOGETONACEAE / Pondweed Family

Curly-Leaved Pondweed

Potamogeton crispus

Other common name: Curly pondweed

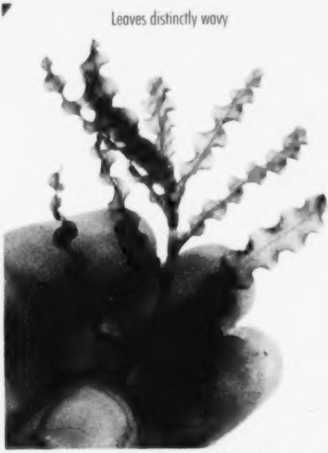


Photo: Peter W. Bergstrom, National Oceanic and Atmospheric Administration/Department of Commerce

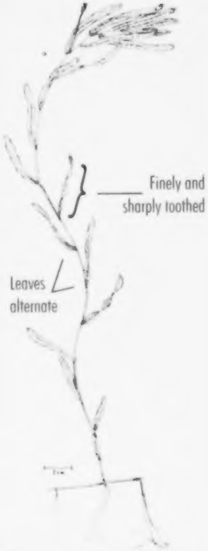


Illustration: University of Florida/IFAS Center for Aquatic and Invasive Plants

Description: Submerged, perennial, rooted aquatic plant. **Leaves:** submersed, alternate, oblong, rounded at apex, green to red brown in colour, 3-8 cm long, 0.75-1.5 cm wide in spring and early summer but more narrow, 0.5-0.75 cm, in winter and early spring; distinct margins that are undulating (wavy), finely and sharply toothed[1,2,3]. **Flowers:** emergent, small, red-brown in colour, several to many, stalkless on terminal spike. Flowers between May and June.[1,3,4] **Fruit:** curved beak to 2 mm long[1].

Similar species: None. The oblong leaves with curly and toothed edges of this species distinguish it from other aquatic plants in Canada[3].

Pot-pot-cri

HABITAT: Freshwater lakes, rivers, streams, ponds, ditches, and canals, but also brackish waters; rooted in silt or clay, and sometimes gravel or sand[2,3,4].

INTRODUCED RANGE: Found in southern Ontario, southern Canadian Shield, and Georgian Bay-Severn River area[3,5]. Also occurs in southwestern Québec, southern British Columbia, Alberta, sparsely in south-central Saskatchewan, and recently in a pond in southern New Brunswick, as well as most of the United States, parts of Central and South America, Africa, and Australia[2,3,4,6,7].

NATIVE RANGE: Eurasia[2].

PATHWAY OF INTRODUCTION AND SPREAD: The pathway by which the species was first introduced to North America in the mid-1800's and to Canada, in Toronto, near the end of the 19th century, is not known[3]. In some places, intentional planting of curly-leaved pondweed for waterfowl and wildlife habitat has occurred[8]. The plant can spread between waterbodies via plant material such as plant fragments or fruit that are transported with boats, boat trailers and other equipment (e.g., fishing or scuba gear).

IMPACTS: Forms dense stands which cover and dominate large areas, crowding out other species, impeding water flow, restricting recreational activities in the water, and potentially altering oxygen levels with impacts on fish[3].

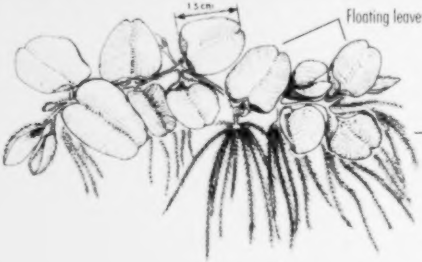
SALVINIACEAE / Floating Fern Family

Watermoss - *Salvinia* spp.

Eared watermoss (giant salvinia)	*Salvinia auriculata*
Water fern (water spangles)	*Salvinia minima*
Giant salvinia (kariba weed, water fern)	*Salvinia molesta*
Floating watermoss (eared watermoss)	*Salvinia natans*

Photo: Vic Ramey, University of Florida/ IFAS Center for Aquatic and Invasive Plants

Illustration: University of Florida/IFAS Center for Aquatic and Invasive Plants



DESCRIPTION*: Small, free-floating, annual or perennial aquatic ferns. **Leaves:** 3 in a whorl, but appearing paired with 2 floating and 1 submersed. Floating leaves green, simple, rounded, up to 4 cm in diameter, flat, entire, short-petioled or without, upper surface with erect, forked hairs. Submersed leaves root-like, finely dissected, with petiole.[1,2,3] **Stems:** creeping, branched, bearing hairs[1]. **Roots:** no true roots[1].

SIMILAR SPECIES: Native duckweeds (*Spirodela polyrrhiza, Lemna trisulca, Lemna minor*) are much smaller, have leaves that lack hairs and have short, unbranched roots, whereas the floating leaves of *Salvinia* have upper surface hairs and plants lack true roots[1,3,4]. Non-native mosquito fern (*Azolla pinnata*: Azo-azo-pin in this guide) has minute leaves (1-2 mm), scale-like and overlapping, and plants appear triangular in shape compared to *Salvinia* with leaves larger (to 4 cm diameter), simple and rounded[1,2,3,5].

Habitat: Generally found in open and still waters, flood canals, rivers, lakes, reservoirs, and swamps[2,3].

Introduced Range: Not known from Ontario or Canada, to date. Some species reported in northeastern states (*S. minima* and *S. natans* in New York and Massachusetts), southern states (*S. minima, S. molesta*), and Puerto Rico (*S. auriculata*)[6]. Found mostly in tropical and sub-tropical regions of the world[1].

Native Range: Warm temperate to tropical regions of the world[7].

Pathway of Introduction and Spread: Watermosses are used as ornamental plants of ponds and outdoor water gardens where they may intentionally be planted near or along shorelines and escape into new areas as plant material is discarded into a waterway and/or carried off by flooding during rain events. They may also be sold as aquarium plants or arrive as contaminants in imports of other aquatic horticultural plants[8], and subsequently escape into the environment through dumping of aquarium contents into waterways. They can spread between waterbodies via plant fragments that are transported with boats, boat trailers and other equipment (e.g., fishing or scuba gear). This plant material can give rise to new plants and populations by multiplying vegetatively.

Impacts: Invasions of *S. molesta* in other parts of the world have involved hundreds of square kilometres of water covered in continuous, dense floating mats of the plant sometimes up to 1 m thick, severely impacting the aquatic ecosystem (habitat, community, species, nutrients) and essential means of transportation, food, water, livelihood, etc.[2].

*A general description of the family and its single genus, *Salvinia*, is provided here because (1) identifying specimens to species is complicated, requiring identification of very small characteristics under magnification, and (2) although possibly 4 species occur in North America (3 introduced, 1 native to Mexico), none are known from Ontario or Canada, to date[1,6,9], therefore, any plant found that is suspected of being a species in this family should be collected and reported as per section 3.0 Reporting Procedure in this guide.

TRAPACEAE / Water-Chestnut Family

European Water Chestnut

Trapa natans

Other common names: Water chestnut, water nut, water-caltrop

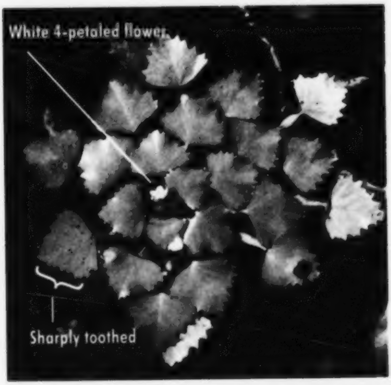
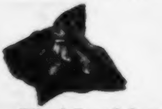


Photo: Michael D. Naylor, Maryland Department of Natural Resources

Photo: Daniel Brunton



"Woody" nut 3-4 cm

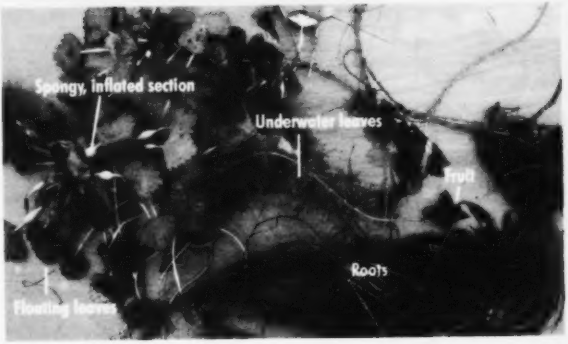


Photo: Stephane M. Bailleul

DESCRIPTION: Floating, annual aquatic plant, rooted in substrate or free-floating[1]. **Floating leaves:** alternate, forming densely crowded rosette up to 30 cm in diameter; blade rhomboid, 2-5 cm wide, margins sharply toothed; elongate petioles to 15 cm long, with spongy, swollen section[1,2,3]. **Submersed leaves:** opposite, finely dissected, feather-like[3,4]. **Flowers:** emergent, perfect, regular; 4 white petals, 8 mm long; borne in axils of floating leaves on short flower stalk[1]. Flowering can begin in the summer and occur until frost arrives[4]. **Fruit:** "woody" nut, 3-4 cm wide, with 4 sharp barbed spines[1,3]. **Stem:** submersed portion up to 5 m but usually 1 m long, elongate internodes with underwater feather-like leaves and sometimes bearing slender, unbranched roots; emergent portion short, bearing rosette of leaves[1,2,4].

SIMILAR SPECIES: None.

HABITAT: Lakes, rivers, streams, ponds with soft substrate, full sun, and nutrient-rich waters; most abundant in 2 m deep water but can be found in water up to 4 m deep[2].

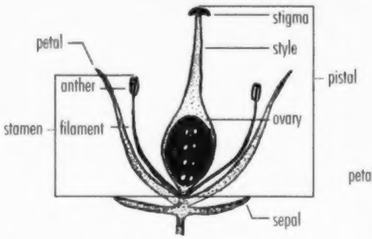
INTRODUCED RANGE: Recently established in Ontario, in a bay connected to the Ottawa River in Voyageur Provincial Park[5]; also found in southwestern Québec along Rivière du Sud[4,6]. It is found in northeastern United States[2], as close as the south shore of Lake Ontario in New York and the Lake Champlain watershed of New York and Vermont[4].

NATIVE RANGE: Eurasia and Africa[1].

PATHWAY OF INTRODUCTION AND SPREAD: European water chestnut was first introduced to the United States in the late 19th century, likely as an ornamental garden plant. The first record in Canada was from southwestern Québec in 1998[4]. The fruit has been used for medicinal purposes (e.g., rheumatism, sunburn)[4] and, as well, the plant is used as an ornamental of ponds and outdoor water gardens where it may intentionally be planted near or along shorelines and escape into new areas as plant material is discarded into a waterway and/or carried off by flooding during rain events. It can spread between waterbodies via plant material such as fragments, fruits or seeds that are transported with boats, boat trailers and other equipment (e.g., fishing or scuba gear).

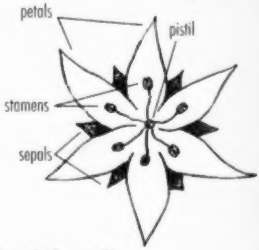
IMPACTS: Forms dense, large floating mats, shading out submerged plants and other organisms, and interfering with recreational activities such as boating, fishing and swimming; the hard nut with barbed spines which accumulate on shore can cause injury when stepped on[2].

Parts of a Typical Flower

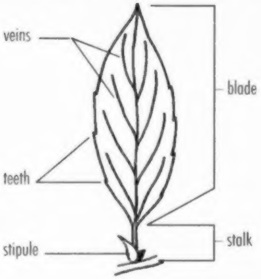


Cross-section; Side View

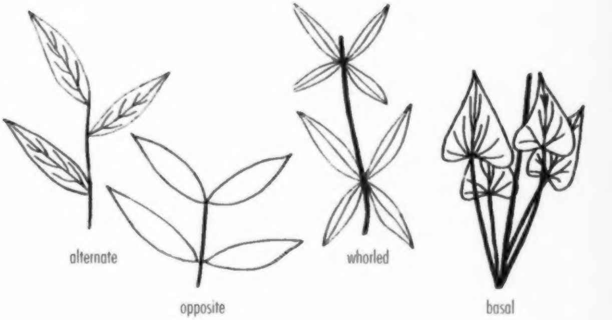
Top View



Parts of a Typical Leaf



Leaf Arrangement



From: S.G. Newmaster, A.G. Harris, and L.J. Kershaw. 1997. Wetland Plants of Ontario. Lone Pine Publishing and Queen's Printer for Ontario. Edmonton, Alberta.

Glossary

Aerenchyma – type of plant tissue with thin-walled cells containing large intercellular spaces

Annual – a plant that completes its life cycle in one year – germinating from seed, flowering, setting seed, and dying in one growing season

Apex – a tip

Axillary – in an axil, e.g., the angle between leaf and stem

Axis – central line along which lateral parts of the plant are arranged

Beak – a comparatively short and stout terminal appendage on a thickened organ like a seed or fruit

Biennial – requiring two years to complete its life cycle, usually involving vegetative growth in the first year and reproduction (flowering, fruiting) and senescence (death) in the second year

Bract – a specialized, reduced leaf associated with a flower or flower cluster

Bulbil – a small, bulb-like structure (vegetative propagule) produced by some plants in the axils of leaves, inflorescences or rhizomes

Culm – a plant stem

Dichotomous(ly) – forking in pairs

Dissected – divided into many small segments

Elongate – considerably longer than wide

Emergent – partly submersed in water, partly above water surface

Entire – a continuous edge without teeth or lobes

Ephemeral – not permanent; existing for a short time

Glume – one of a pair of bracts, found at the base of a grass spikelet, which do not subtend flowers

Inflorescence – a flower cluster; the arrangement of flowers on the axis

Internode – the part of a stem between two nodes

Ligule – collar-like appendage at the upper edge of a leaf sheath

Linear – very long and narrow, with parallel edges

Midvein – the central vein of a leaf

Nectary – a gland that secretes nectar

Node – the place where a leaf or branch is attached to a stem

Oblong – shaped like a geometrical rectangle (other than a square)

Palmate(ly) – lobes or leaf segments radiating from a common point

Pedicel – the stalk of a single flower in an inflorescence

Perennial – a plant that lives for more than two years

Perfect – describes a single flower that has both male (stamen) and female (pistil) reproductive organs

Petiole – a leaf stalk

Pinnate(ly) – leaflets (or segments) arranged on two sides of an axis

Plicate – having folds, usually lengthwise

Prickle – a sharp outgrowth

Regular – describes a flower that is symmetrical when divided in half or into equal parts through the middle

Rhizome – an underground stem, usually elongate

Riparian – adjacent to a river or stream, including shores and floodplains

Rosette – a cluster of leaves or other organs radiating from a centre point

Simple – not divided or branched into parts

Spike – an elongate inflorescence with stalkless flowers

Spikelet – the smallest unit of an inflorescence

Stipule – an appendage at the base of a leaf stalk, usually leaf-like

Stolon – an elongate, creeping stem spreading horizontally on the surface of the ground, usually rooting at nodes or tips

Submerged (Submersed) – under water

Tepal – a sepal or petal; the term is applied when these structures are not easily distinguished from one another

Terminal – at the end, or tip of

Turion – a winter bud; sometimes a scaly, bulb-like growth from a bud on a rhizome or other vegetative organ

Whorl – a ring of 3 or more similar structures (e.g., leaves) radiating from a node or common point

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Gleason, H.A. and A. Cronquist. 1991. Manual of vascular plants of Northeastern United States and adjacent Canada: Second edition. New York Botanical Garden. Bronx, New York.

Newmaster, S.G., A.G. Harris, and L.J. Kershaw. 1997. Wetland plants of Ontario. Lone Pine Publishing and Queen's Printer for Ontario. Edmonton, Alberta.

Channeled Apple Snail

Pomacea canaliculata

Other common names: Golden apple snail, miracle snail, canaliculate apple snail

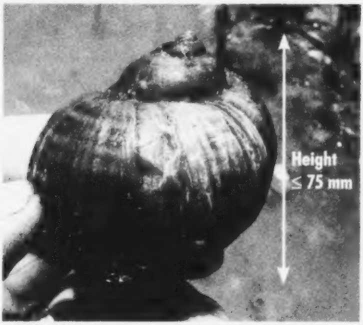
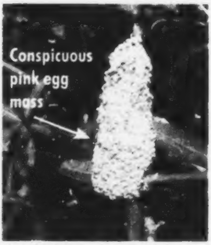


Photo: David Britton



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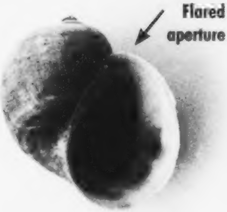


Photo: Bill Frank

DESCRIPTION: Largest freshwater snail in North America; amphibious gastropod with siphon for breathing while submerged. **Size:** very large, shell height 45-75 mm. **Shape:** spherical shell with 5-6 rounded whorls, deep indents between whorls, and deeply channelled growth lines. Shell may appear dented. **Colour:** shell color generally brownish or greenish but can vary from dark, almost black, to pale cream, often with spiral banding patterns around the whorls. **Operculum:** flared aperture, ear-shaped operculum with concentric growth lines. **Eggs:** conspicuous pink egg masses on plant or other structures above water surface often first sign of channelled apple snail.[1,2,3]

SIMILAR SPECIES: Invasive banded and Chinese mysterysnails (*Viviparus georgianus* and *Cipangopaludina chinensis*: Viv-viv-geo and Viv-cip-chi in this guide) might resemble a channelled apple snail but they are less spherical in shape and usually much smaller[1]. Other species of apple snail in the southern United States are very similar and may be difficult to separate because of high colour variation within species[3].

HABITAT: Found in lakes, ponds, canals, and swamps[4]. Able to breathe in water as well as on land, and can survive burrowed in mud for long periods of drought[1,2,5].

INTRODUCED RANGE: Not known from Ontario or Canada, to date[6]. In the United States, it occurs in several southern states including Alabama, Florida, Texas, California, and Hawaii[7,8]. Also documented in Dominican Republic, Asia, Guam, Papua New Guinea, and Taiwan[3].

NATIVE RANGE: South America, including Brazil, Bolivia, and Argentina[3].

PATHWAY OF INTRODUCTION AND SPREAD: Deliberately introduced into the aquaculture industry for food in the United States[5]; consumed in Canada, but only through the imported frozen food industry. The snail is also available in North America through the aquarium industry. Deliberate or unintentional introductions of snail eggs or adults may be associated with the aquaculture or aquarium industries[2] . Bait buckets, live wells, bilge water, boat hulls/motors/trailers, and other equipment (e.g., fishing or scuba gear), which could potentially be contaminated with snails, may help in their transport and spread between waterbodies.

IMPACTS: Feeds voraciously on aquatic plants, can modify habitat, and is a serious wetland agricultural pest threatening the taro crop industry in Hawaii and rice production in Asia[5,9,10,11,12]. The snail also serves as a vector for bacteria and parasites, which potentially includes a nematode parasite causing meningoencephalitis in humans[2].

CAMBARIDAE / Crayfish Family

Rusty Crayfish

Orconectes rusticus

Other common name: None

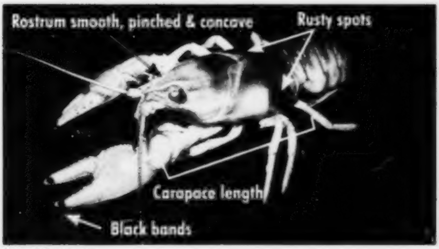


Photo: Dale Westaby

Lateral view of 1st copulatory stylet

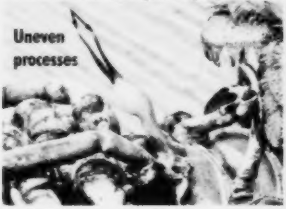


Photo: Premek Hamr

Underside of male

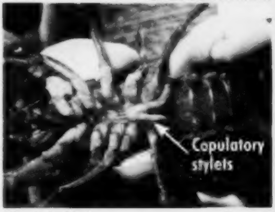


Photo: Michael Butler

DESCRIPTION: Large, aggressive crustacean. **Size:** carapace length 14-45 mm (up to 54 mm). **Body features:** hard carapace covers head and thorax. Rostrum pinched and distinctly concave; upper surface smooth. 5 pairs of thoracic legs; last pair modified into large claws. First copulatory stylet (of male) is straight to slightly curved; processes are fairly long (almost ½ total length of stylet) and uneven in length. **Colour:** variable, rusty patches on either side of carapace might be prominent; also red stripes along abdominal segments might be present. Black bands on claws tips usually distinctive.[1,2,3]

SIMILAR SPECIES: Native northern clearwater crayfish (*O. propinquus*) has a small yet distinctive ridge on the upper surface of a pinched rostrum, lacks rusty spots on the carapace and black bands on the claws, and the copulatory stylets are relatively short and stubby; however, this species can hybridize with rusty crayfish, obscuring some distinguishing characteristics. Native virile crayfish

(*O. virilis*) has a mottled pattern on its back, lacks a pinched rostrum, and has very long stylets (processes ≥ ½ total length of stylet). Introduced obscure crayfish *(O. obscurus)* also lacks the pinched rostrum and black claw bands, and has very short stylets (processes < ½ total length of stylet).[1]

HABITAT: Occurs in a wide range of habitats including wetlands, ponds, lakes, and rivers; prefers areas with rocks and logs, with clay silt and gravel bottoms. Reproduction occurs above 5°C[4,5].

INTRODUCED RANGE: First documented in Ontario in the early 1960's, it now occurs throughout southcentral and southeastern Ontario (including Manitoulin Island, Magnetawan River, Kawartha Lakes drainage, Ottawa drainage), as well as in some northwestern regions of the province[1,5,6,7,8]. It is reported in western Québec and southwestern New Brunswick[2]. In the United States, its range has expanded as far west as North and South Dakota, east to Maine, and south to New Mexico[4]. Not known to occur outside North America.

NATIVE RANGE: Ohio River system running through Ohio, Kentucky, Tennessee, Indiana, and Illinois, in the United States[4].

PATHWAY OF INTRODUCTION AND SPREAD: Release or escape of unused rusty crayfish from bait buckets and fishing lines are thought to be primary pathways. The species may have been stocked in some lakes for commercial harvest. Aquarium releases of rusty crayfish collected as pets may occur as well as releases of rusty crayfish distributed as specimens through the scientific supply trade[4].

IMPACTS: Competes with native crayfish and fish for resources, consuming invertebrates and large amounts of vegetation, reducing local invertebrate abundance and macrophyte biomass and species richness[9,10,11,12]. Its negative effect on abundances of fish species is likely the result of habitat (vegetation) reduction, competition for food, and direct predation on fish eggs[11]. The species displaces native crayfishes and can become the dominant crayfish species[10,11,13,14,15]. Hybridization between rusty and northern clearwater crayfishes may also hasten local losses of native crayfish species[16].

Cam-orc-rus

CERCOPAGIDAE / Waterflea Family

Spiny Waterflea

Bythotrephes longimanus

Other common names: Eurasian spiny water flea; former scientific name was *B. cederstroemi*

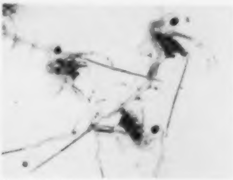


Photo: Peter Johnson

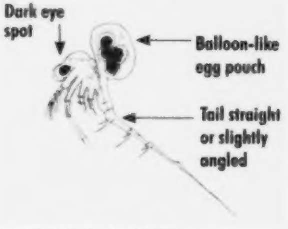


Illustration: Michigan Sea Grant Program

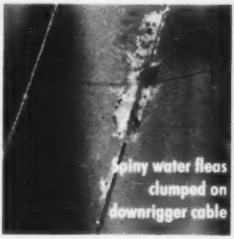


Photo: Jeff Gunderson

DESCRIPTION: Predatory cladoceran that collects in jelly-like masses on fishing lines, downrigger cables, or nets; masses may appear as clusters of tiny pins with black dots. **Size:** total length 10 mm, of which the tail spine comprises ~60%. **Body features:** tail spine is straight or slightly angled from body, with 1-3 pairs of barbs, and a straight needle-like tip. Head has single, large, dark, compound eye. Dorsal egg pouch is balloon-like in shape. Microscope often needed to differentiate these characteristics. **Colour:** body might have orange, blue and green colouring; red stripe runs half the length of tail.[1,2]

SIMILAR SPECIES: Invasive fishhook waterflea (*Cercopagis pengoi*: Cer-cer-pen in this guide) has a longer tail spine, comprising ~80% of body length, with a distinctive loop at the tip, and its egg pouch is elongated and pointed[2,3]. The only native relative, *Polyphemus pediculus*, is much smaller with a short body and tail spine, and much bigger eye[4]. Native cladocerans (e.g., *Daphnia mendotae*) may look superficially similar but have much shorter tail spines that are <25% of their total length[1].

HABITAT: Prefers large, deep, clear, oligotrophic lakes but will occur in slightly eutrophic waters[2,3,5]. Tolerates water temperatures 5-28°C; migrates vertically in water column, to deeper, cooler waters in the day and surface waters at night[6,7]. Greater abundances are likely found where refuge from fish predators is present[8].

INTRODUCED RANGE: First reported in Lake Ontario in 1982, and found in all of the Great Lakes by 1987; it now occurs in over 100 inland lakes in Ontario[5,7,9,10,11,12]. Not reported elsewhere in Canada. In the United States, reported in inland lakes for states bordering the Great Lakes[13]. Also introduced to many European lakes[3].

NATIVE RANGE: Eurasia[3].

PATHWAY OF INTRODUCTION AND SPREAD: Introduced to the Great Lakes probably via ballast water discharge of commercial shipping vessels[10,14]. It spread to inland lakes likely through angling and recreational boating via live wells, bait buckets, fishing lines, downriggers or other equipment used in the water and which can be coated with eggs and adults[11,15]. Spiny waterflea primarily reproduces parthenogenically and therefore has the capacity to colonize quickly with a single female[16]. Sexual reproduction produces 'resting eggs' which overwinter, can remain dormant for long periods of time, and may be transported via angling and boating activities[11,17].

IMPACTS: Since spiny waterflea invaded, significant changes to zooplankton communities have occurred in the Great Lakes and many inland lakes, including disappearances of species and declines in species abundance, density, richness, and biomass[8,14,18,19]. Because of intense predation on smaller species by spiny waterflea, the cladoceran community have undergone a shift to larger species[8,14,19,20]. Other zooplankton predators may be affected directly through competition for food or indirectly because of a shift in prey items available. Small fish have difficulty consuming spiny waterflea and larger fish that prey on the species may experience reduced growth rates because the waterflea spines are indigestible (accumulate in the stomach) and do not offer any nutritional value[21]. Also, the species can attach to and foul fishing lines, downrigger cables, and other equipment used for fishing[15].

CERCOPAGIDAE / Waterflea Family

Fishhook Waterflea

Cercopagis pengoi

Other common name: None

Female with egg pouch

Photo: NOAA, Great Lakes Environmental Research Laboratory

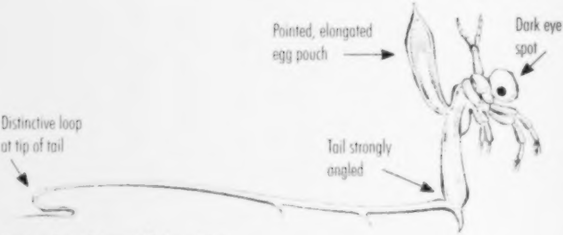


Illustration: Ontario Federation of Anglers and Hunters

DESCRIPTION: Predatory cladoceran that collects in cotton-like masses on fishing lines. **Size:** total length 10 mm; tail spine comprises ~80% of total length. **Body features:** tail spine is strongly angled (~90°) from body, with 1-3 widely spaced pairs of barbs, and a unique loop or "hook" at the tip. Head has single, dark, compound eye. Dorsal egg pouch elongated and pointed. Microscope often needed to differentiate these characteristics. **Colour:** transparent.[1]

Note, in this species, another morph exists which usually occurs earlier in the season during spring but has a much shorter tail that lacks the loop at the end and bears up to four paired barbs[2].

SIMILAR SPECIES: Invasive spiny waterflea (*Bythotrephes longimanus*: Cer-byt-lon in this guide) has a relatively shorter tail spine (~60% of total length), lacks the loop at the tip of the tail, and the egg pouch is balloon-like in shape[3,4]. Native cladocerans (e.g., *Daphnia mendotae*) have short tails which are less than ¼ of their total body length[3].

HABITAT: Found in open deep waters, preferring the upper, warmer water layer (epilimnion) but able to tolerate a wide range of water temperatures from approximately 8-30°C[1,5,6].

INTRODUCED RANGE: First recorded in Lake Ontario in 1998, the St. Lawrence River by 1999, and Lake Erie by 2001[1,7]. Not reported elsewhere in Canada, to date. In the United States, occurs in Lake Michigan, Lake Erie and the connected Detroit River, and several 'Finger Lakes' in New York State[2,8,9]. Also introduced to waterways and reservoirs in Eastern Europe and the Baltic Sea[4].

NATIVE RANGE: Ponto-Caspian region of Eurasia[1].

PATHWAY OF INTRODUCTION AND SPREAD: Introduced probably via ballast water discharge of a commercial shipping vessel, with Great Lakes populations derived from the Baltic Sea[1,10]. Fishhook waterflea primarily reproduces parthenogenically and therefore has the capacity to colonize quickly with a single female[1]. Sexual reproduction produces 'resting eggs' which overwinter and may be transported, along with adults, to inland lakes in bait buckets, live wells, mud, bilge water, or on fishing and other equipment[11].

IMPACTS: Predation by fishhook waterflea on small native zooplankton has likely led to the declines observed in several zooplankton species in Lake Ontario[6,12]. The fishhook waterflea may compete with native planktivorous fish or other zooplankton predators for food[2,6]. Because of its barbed tail, the species attaches to fishing gear and clogs nets and trawls, fouling equipment used for recreational and commercial fishing[1,13,14].

CORBICULIDAE / Little Basket Clam Family

Asian Clam

Corbicula fluminea

Other common names: Asiatic clam, prosperity clam, gold clam

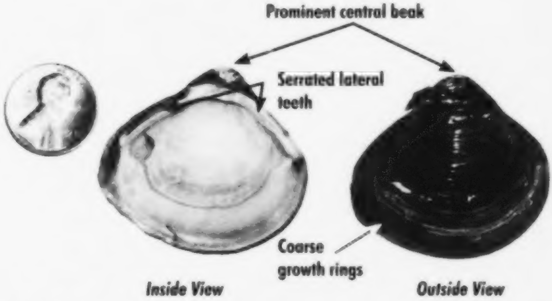


Photo: Jason Goeckler

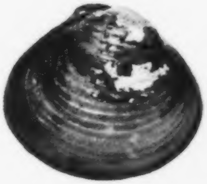


Photo: U.S. Geological Survey,
Florida Integrated Science Centre

DESCRIPTION: Small freshwater clam. **Size:** shell usually less than 2.5 cm, but up to 6.5 cm long. **Shape:** shell triangular, relatively thick, with coarse growth rings. On shell interior, lateral teeth are finely serrated (visible with hand lens). **Colour:** periostracum thick, deciduous, yellowish- to blackish-brown. **Juveniles**: microscopic, free-floating larvae, called veligers, are "D"-shaped and less than 1 mm in length.[1,2,3,4]

SIMILAR SPECIES: Native and introduced fingernail or pea clams (Sphaeriids) may resemble Asian clam, but their lateral teeth are smooth vs. serrated in Asian clam. Sphaeriids are also generally smaller, have thinner shells, and less prominent growth rings.[1,3]

Habitat: Found in wide range of habitats, including lakes, ponds, streams, and canals. Prefers flowing freshwater with mixed mud-sand substrate, but inhabits rock and gravel substrates as well[4,5]. Tolerates low temperatures well (e.g., 0-2°C)[6]; however, temperatures of 16°C or higher are needed for reproduction[1,7].

Introduced Range: Not known from Ontario, to date, but documented in Lakes Superior, Michigan and Erie from the United States[8,9]. Elsewhere in Canada, dead specimens were found in British Columbia in the early 1920's[10]. In the United States, it is documented in 40 states[9]. It is also found in South America and Europe[5].

Native Range: Southeast Asia, Turkey, Japan, Indonesia, Australia, Africa[5].

Pathway of Introduction and Spread: May have been introduced into the United States as a food item for humans[7,9]. Deliberate or unintentional introductions of the clam may be associated with the aquaculture or aquarium industries. Bait buckets, live wells, bilge water, boat hulls/motors/trailers, and other equipment (e.g., fishing or scuba gear), which could potentially be contaminated with clams, may help in their transport and spread between waterbodies.

Impacts: Asian clam filters suspended matter from the water column, which significantly increases water clarity, leads to excessive plant growth and alters lake nutrient regimes. It may compete with native molluscs for food and habitat[5]. The clam can infest and interfere with irrigation systems and canals, and block water flow through industrial raw water intake pipes[7,11].

DREISSENIDAE / Dreissenid Mussel Family

Quagga Mussel

Dreissena bugensis

Other common name: None

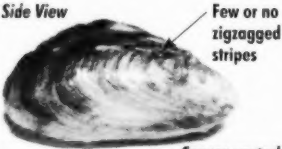


Photo: Michigan Sea Grant, www.miseagrant.umich.edu

Photo: Dave Britton

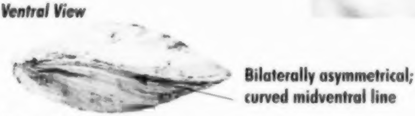


Photo: Myriah Richardson (USGS)

Description: Small, variably striped, freshwater mussel. **Size:** small, up to 3 cm long. **Shape:** round to triangular in cross-section. Ventral surface convex. Left and right valves asymmetrical with curved midventral line. **Colour:** variable, pale, may have coloured bands, bars, or few to no zigzagged stripes. **Juveniles**: microscopic larvae, called veligers, are round in shape and free-float for up to 5 weeks; during post-veliger stage, foot is formed to attach to substrate.[1,2]

Similar Species: Introduced zebra mussel (*D. polymorpha*: Dre-dre-pol in this guide) is a close relative but has a flat to concave ventral surface, a prominent ridge, and conspicuous zigzagged stripes[1].

Habitat: Found in freshwater lakes, reservoirs, ponds, quarries, and slow-moving or sluggish rivers; can occur in shallow, warm waters as well as deeper, cool waters[1,3,4]. Attaches to hard surfaces such as rocks, docks, cement, wood, and macrophytic vegetation or may partially bury itself into soft sediments[5,6]. Quagga mussel reproduction can occur at low water temperatures, as cold as 4-9°C[1,7].

INTRODUCED RANGE: In Ontario, it was first reported in Lake Erie in 1989, and now occurs in Lakes Ontario, Huron, and Simcoe, the Rideau River, and several locations along the St. Lawrence River[8,9,10]. It is also reported in Québec along the St. Lawrence River. In the United States, it is documented along the south shores of all the Great Lakes, Lake St. Clair, in a few northeastern states, one location along the Mississippi, as well as in California[9] and Southern Nevada[11]. It also spread through Europe[2].

NATIVE RANGE: Tributary of the Black Sea, Ponto-Caspian region of Eurasia[2].

PATHWAY OF INTRODUCTION AND SPREAD: Originally introduced by ballast water transported in commercial vessels and potentially on fouled ship hulls[1,12,13]. Veliger and adult mussels spread between waterbodies when they are transported in bait buckets, live wells and bilge water or attached to boat hulls/motors/trailers and other equipment (e.g., fishing or scuba gear). Adult quagga mussels can survive for up to 22 days out of water if the air is humid and about 15°C in temperature[5].

IMPACTS: Quagga mussel (like zebra mussel) forms colonies in great densities, is able to filter large quantities of plankton from the water column and consequently increase water clarity; it poses competition for food with native organisms; indirectly effects the community structure of plants (from planktonic to macrophytic) and potentially fish[1,6]; dense colonization of mussels in a waterbody has been followed by declines or complete losses in native mussels[1,14]. In the Great Lakes, it may help facilitate the round goby (*Neogobius melanostomus*: Gob-neo-mel in this guide) invasion as it is a food source and component of round goby diet in its native range[6,12]; mussel colonies also provide additional habitat for the invasive gammarid (*Echinogammarus ischnus*: Gam-ech-isc in this guide)[6,9]. Moreover, the mussel pollutes swimming areas with sharp shells and can be a serious biofouler of water intake pipes causing significant cost and safety concerns to industry and municipal water users[1]. Quagga mussel may be replacing zebra mussel populations in some regions of their Great Lakes distribution[4,7].

Zebra Mussel

Dreissena polymorpha

Other common names: Zebra clam, tiger mussel

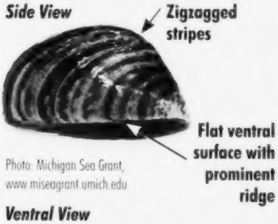


Photo: Michigan Sea Grant, www.miseagrant.umich.edu

Zebra mussels encrust bumper

Photo: Dave Britton

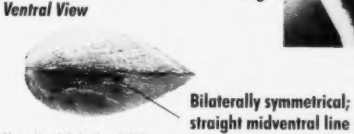


Photo: Myriah Richardson (USGS)

DESCRIPTION: Small, striped, strongly ridged, freshwater mussel. **Size:** usually 2 to 2.5 cm, up to 4 cm in length. **Shape:** shell "D"-shaped or triangular in cross-section. Pronounced ridge, ventral surface flat to concave. Left and right shell valves symmetrical with straight midventral line. **Colour:** black or brown with variable white to yellow striped or zigzagged patterns. **Juveniles**: microscopic larvae, called veligers, are round in shape and free-float for up to 5 weeks; during post-veliger stage, foot is formed to attach to substrate.[1,2]

SIMILAR SPECIES: Introduced quagga mussel (*D. bugensis*: Dre-dre-bug in this guide) is a close relative, but has a convex rather than flat to concave ventral surface, lacks a prominent ridge, and has few to no zigzagged stripes[1].

HABITAT: Found in lakes, rivers, reservoirs, ponds, and quarries. Veligers are free-floating in the water column while post-veligers settle on submerged vegetation and adults tend to settle on hard surfaces such as rocks, docks, cement, wood, and macrophytic plants[3,4]. Settlement cannot easily occur in areas with swift current or strong wave action[1,2]. Greater densities are found at depths shallower than 12 m[4]. Water temperatures greater than 10°C are needed for reproduction[5,6].

INTRODUCED RANGE: In Ontario, zebra mussel was first collected in Lake St. Clair in 1988; it spread to all the Great Lakes and the St. Lawrence River, and is spreading to inland lakes and rivers, including the Rideau Canal and Trent-Severn Waterway[1,7,8]. In the United States, it has spread to many inland lakes in the Great Lakes region and most large navigable rivers in eastern United States, including the Mississippi River[2]. Also spread through most of Europe[1].

NATIVE RANGE: Ponto-Caspian region of Eurasia[9].

PATHWAY OF INTRODUCTION AND SPREAD: Originally introduced by ballast water transported in commercial shipping vessels and potentially on fouled ship hulls[7,9,10]. Adults can only survive out of water for up to five days at 25°C, however, if the air is humid and cooler at 15°C, they can survive up to 22 days out of water[3]. Veliger and adult mussels can spread between waterbodies when they are transported in bait buckets, live wells and bilge water or attached to boat hulls/motors/trailers and other equipment (e.g., fishing or scuba gear).

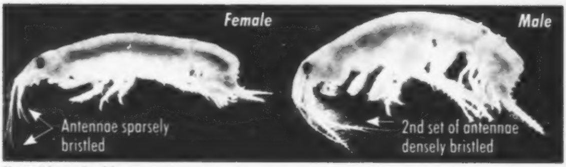
IMPACTS: Forms colonies in great densities and filters large quantities of plankton from the water column; it poses competition for food with native organisms[11]; dense colonization in a waterbody has been followed by declines or complete losses in native mussels[12,13,14]; attachment to native mussels and formation of colonies over top their shells threaten their ability to filter, feed and survive[1,11,14,15]; indirectly effects the community structure of plants (from planktonic to macrophytic) and potentially fish (e.g., walleye which prefer turbid waters) as removal of suspended matter from the water column leads to an increase in water clarity[11]; bioaccumulates high levels of contaminants, which are passed to species higher in the food chain[1,16]; may be a contributing factor to botulism outbreaks in the Great Lakes[17]. Establishment in the Great Lakes has facilitated the invasion of round goby (*Neogobius melanostomus*: Gob-neo-mel in this guide) as it is a food source and component of round goby diet in its native range[11, 18]; also, colonies provide additional habitat for the invasive gammarid (*Echinogammarus ischnus*: Gam-ech-isc in this guide)[11,19]. Pollutes swimming areas with sharp shells[1] and can be a serious biofouler of water intake pipes causing significant cost and safety concerns to industry and municipal water users[20,21].

GAMMARIDAE / Scud Family

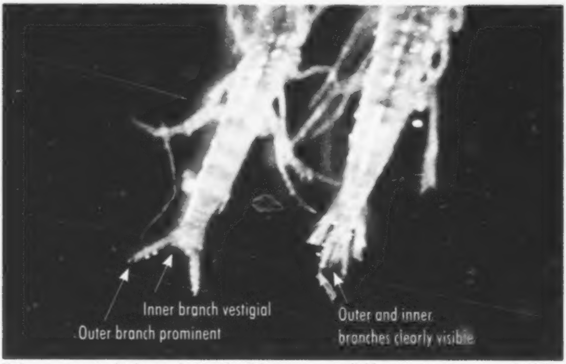
Gammarid

Echinogammarus ischnus

Other common names: Amphipod, gammarus, scud, sideswimmer, freshwater shrimp


Female
Male
Antennae sparsely bristled
2nd set of antennae densely bristled

Photos: Colin van Overdijk



Tail comparison in third uropods: invasive *Echinogammarus* (left) and native *Gammarus* (right).

Photo: Ron Dermott

DESCRIPTION: Small, laterally-compressed macroinvertebrate. **Size:** 8 to 11 mm in length. **Body features:** eyes fairly large, kidney-shaped, and black. Second antennae in males have dense, curly bristles and in females they are sparsely bristled. In the tail fan (observed under low magnification), well developed outer branches with strong 'V' shape and vestigial, inner branches comprise the third uropods. **Colour:** light-orange with reddish antennae.[1,2,3]

SIMILAR SPECIES: Native amphipod, *Gammarus fasciatus*, is best distinguished from the invasive gammarid by its tail shape using a hand lens or low magnification microscope: third uropods of the native species have

Gammarid

Echinogammarus ischnus

Other common names: Amphipod, gammarus, scud, sideswimmer, freshwater shrimp

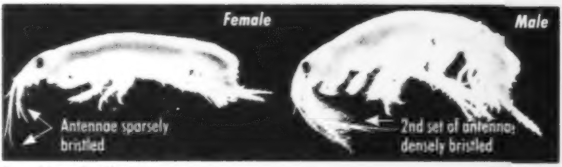
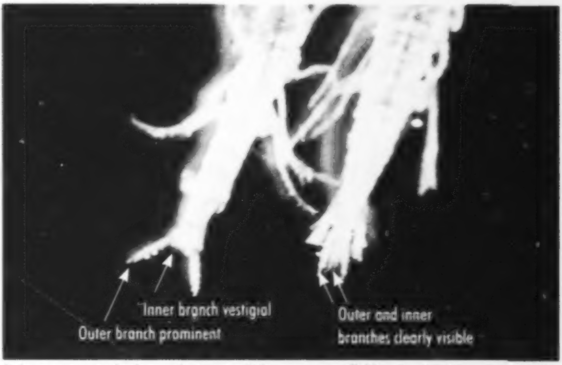

Female
Male
Antennae sparsely bristled
2nd set of antennae densely bristled

Photo: Colin van Overdijk



Tail comparison in third uropods: invasive *Echinogammarus* (left) and native *Gammarus*(right).

Photo: [illegible]

DESCRIPTION: Small, laterally-compressed macroinvertebrate. **Size:** 8 to 11 mm in length. **Body features:** eyes fairly large, kidney-shaped, and black. Second antennae in males have dense, curly bristles and in females they are sparsely bristled. In the tail fan (observed under low magnification), well developed outer branches with strong 'V' shape and vestigial, inner branches comprise the third uropods. **Colour:** light-orange with reddish antennae.

SIMILAR SPECIES: Native amphipod, *Gammarus fasiatus*, is best distinguished from the invasive gammarid by its tail shape using a hand lens or low magnification microscope: third uropods of the native species have less prominent outer branches but clearly visible inner branches. Other native amphipods from the genus *Diporeia* can be distinguished from the gammarids because their third uropod is not well developed.[1]

HABITAT: Found in slow-moving waters of rivers and lakes and habitats with gravel or rocky bottoms[4]. It is often associated with *Dreissena* mussel-encrusted rocks but also has been found on soft-bottom sediments[5,6,7].

INTRODUCED RANGE: First documented in Ontario from western Lake Erie in 1994[7]. It is found in all the Great Lakes, the St. Lawrence River, Niagara River, St. Clair River, and Detroit River[2,4,6,7,8,9,10]. Also spread throughout Europe[2,11].

NATIVE RANGE: Ponto-Caspian region of Eurasia[12].

PATHWAY OF INTRODUCTION AND SPREAD: Likely introduced to the Great Lakes by ballast water discharge from commercial shipping vessels[2]. Its spread to inland lakes may be facilitated if transported via bait buckets, live wells or bilge water, which could potentially be contaminated with the gammarid.

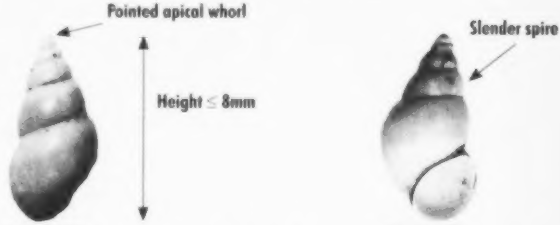
IMPACTS: Evidence suggests it has become the dominant amphipod in some introduced regions and may be replacing the native *Gammarus fasciatus* in the lower Great Lakes[7,10]. It has potential to displace other native macroinvertebrates and alter food webs[11].

HYDROBIIDAE / Spire Snail (or Mud Snail) Family

New Zealand Mud Snail

Potamopyrgus antipodarum

Other common name: Jenkin's spire snail



Posterior View

Photos: Gerry Mackie

Ventral View

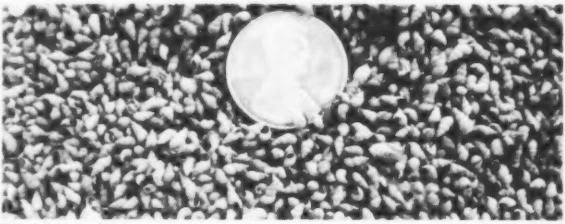


Photo: Daniel L. Gustafson

Description: Small, slender, freshwater snail. **Size:** shell height usually 5 mm but up to 8 mm; height about 2x maximum shell width. **Shape:** spire cone-shaped and slender with pointed apical whorl. Usually 5-6 whorls, up to 8. May have weak keel mid-whorl with coarse hairs. **Colour:** variable, normally horn-coloured but can range from light to dark brown. **Operculum:** ear-shaped with off-centre nucleus.[1,2,3,4]

Similar Species: In Ontario, native snails *Marstonia decepta* (Hydrobiidae) and *Pomatiopsis lapidaria* (Pomatiopsidae), may resemble the New Zealand mud snail but both have a less pointed spire. Other superficially similar elongated snails from the widely-distributed family Lymnaeidae lack an operculum, are generally taller, and have a narrower aperture[5].

HABITAT: Prefers silty sand sediments in freshwater (or slightly brackish) habitats including rivers, reservoirs, lakes, and estuaries. Restricted to permanent waterbodies, although it has tolerated temporary desiccation[2]. Cannot survive freezing temperatures in freshwater but may be able to tolerate temperatures just below 0°C in low salinity waters[6].

INTRODUCED RANGE: In Ontario, it is reported in Lake Superior at Thunder Bay, Lake Ontario near Niagara and Kingston, and in the St. Lawrence River[2,7,8]. It is not known from elsewhere in Canada, to date. In the United States, the snail occurs in several northeastern and western states and is reported for Lake Erie[8,9]. Also found in Australia and Europe[8].

NATIVE RANGE: New Zealand[2,4].

PATHWAY OF INTRODUCTION AND SPREAD: The first record of New Zealand mud snail for North America was in 1987 in Idaho and for Lake Ontario it was 1991 in New York. Its introduction was likely via ballast water transport on commercial shipping vessels and/or associated with the movement of aquaculture products (e.g., trout eggs, live fish)[2]. Its spread between waterbodies may be facilitated if transported via bait buckets, live wells, bilge water, boat hulls/motors/trailers, and other equipment (e.g., fishing or scuba gear) which could potentially be contaminated with the snail. The species can become established in a new waterbody with the introduction of a single individual since females can reproduce asexually, without a mate (parthenogenesis)[2,10].

IMPACTS: New Zealand mud snail reaches high densities, e.g., up to 300,000 individuals/m^2 in some North American populations[3,11], and can be a dominate species in secondary production among benthic invertebrates, suggesting possible impacts on the food web[12]. In experiments, high densities have been associated with low colonization of other macroinvertebrates, potentially indicating New Zealand mud snail competes for resources with native species[11].

MYSIDAE / Opossum Shrimp Family

Red Mysid

Hemimysis anomala

Other common names: Bloody red shrimp, red mysis, hemimysis

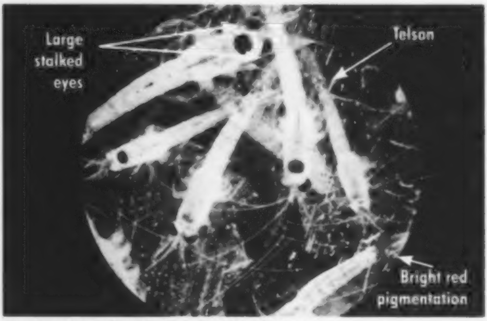
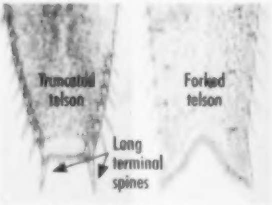


Photo: Steven Pothoven, Great Lakes Environmental Research Laboratory

Photo: Gary Fahnenstiel, Great Lakes Environmental Research Laboratory



Telson of red mysid (left) and native mysid (right) under low magnification. Photos: Steven Pothoven, Great Lakes Environmental Research Laboratory

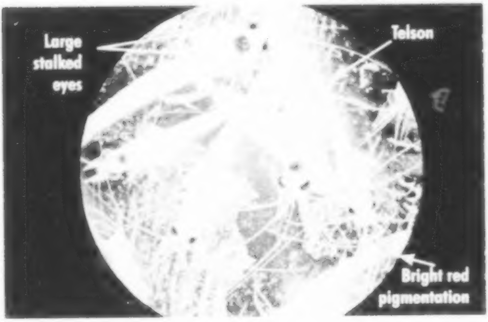
Description: Small macroinvertebrate that may be observed forming reddish swarms during daylight hours in shadows of piers, boats, or breakwalls. **Size:** length 6.5-11 mm. **Body features:** large, black, stalked eyes. Soft carapace covers head and thorax, with 8 pairs of thoracic legs. Telson (observed under low magnification) is truncated (uncleft) with two terminal, prominent spines and short spines along the outer margins. **Colour:** may have bright red to orangish-red pigmentation but can change to ivory-yellow and almost transparent.[1,2,3,4]

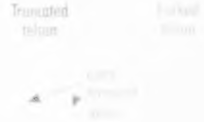
Similar Species: Native opossum shrimp (*Mysis relicta*, which recently may be referred to as *Mysis diluviana* in some literature[5]) looks very similar but its telson is forked

Red Mysid

Hemimysis anomala

[illegible]





[illegible]

Description: [illegible] **Size:** [illegible] **Body features:** [illegible] **Colour:** [illegible]

Similar Species: [illegible]

and lacks long terminal spines compared to red mysid in which the telson is truncated with two prominent spines[1,2,4]. The unique swarming behaviour of red mysid is unlikely to be confused with anything else in the Great Lakes.

HABITAT: Found in brackish or freshwater, in slow-moving waters with hard bottom substrates (rocks, shells), and less frequently on finer or soft bottom substrates[4]. During the day, it actively avoids direct sunlight, swarming in shaded areas and rocky crevasses[3] (particularly during late summer and fall[7]) or migrating to deeper waters; at night, red mysid moves higher in the water column, up to surface waters[1,8]. May be found to 50 m in depth[2].

INTRODUCED RANGE: In Ontario, red mysid was first found in Lake Ontario at Pickering in 2006; it is being reported from several other locations on Lake Ontario and Lake Erie[9]. Not known elsewhere in Canada, to date. In the United States, occurrences have been reported from Lakes Ontario and Erie in New York, and Lake Michigan in Michigan, Illinois, and Wisconsin[9]. It is also spread across Europe to the Baltic Sea and the United Kingdom[3,10].

NATIVE RANGE: Ponto-Caspian region of Eurasia[4].

PATHWAY OF INTRODUCTION AND SPREAD: The first record of the species in North America was from the Lake Michigan basin in Michigan, in 2006[4]. It was likely introduced to the Great Lakes via ballast water discharge from commercial shipping vessels[11]. Its spread between waterbodies may be facilitated by inter-basin transfer or if transported via bait buckets, live wells, bilge water, boat hulls/motors/trailers, or other equipment used in the water.

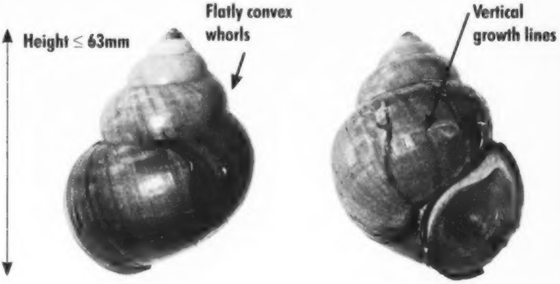
IMPACTS: Red mysid consumes phytoplankton and zooplankton, and it was estimated that swarms contained more than 500 individuals/m^3 at the docking site where the species was first reported in the Lake Michigan basin[1,4,8]. This new invader might potentially alter the plankton community through predation on or resource competition with native zooplankton or planktivorous fish.

VIVIPARIDAE / Mysterysnail Family

Chinese Mysterysnail

Cipangopaludina chinensis

Other common names: Oriental mysterysnail, Chinese vivipara, rice snail, Asian apple snail



Dorsal View **Ventral View**

Photos: Gerry Mackie

Photo: Dave Britton

DESCRIPTION: Largest freshwater snail in Canada. **Size:** shell height up to 6.5 cm. **Shape:** spherical, inflated, up to 7 flatly convex whorls separated by prominent sutures. Shell contains fine vertical and horizontal lines, with fine to moderate dents or indentations. **Colour:** brownish to olive-green. **Operculum:** oblong with concentric growth lines. **Juveniles:** young snails can be held in uterus until 4-whorl stage.[1,2]

SIMILAR SPECIES: Introduced banded mysterysnail (*Viviparus georgianus*: Viv-viv-geo in this guide) is generally smaller (up to 3.5 cm in height), has strongly convex whorls, and has prominent dark horizontal bands[3,4]. Introduced Japanese mysterysnail (*C. japonicus*), documented in southern Lake Erie, looks so similar to *C. chinensis* that some consider them synonymous[5]. Native brown mysterysnail (*Campeloma decisum*) is generally smaller in size, has a more oblong spire, a blunt or corroded terminal whorl, and lower whorls that are less inflated or convex[1].

HABITAT: Found in shallow, quiet waters of ponds, marshes, lakes, canals, and slow-moving rivers with some vegetation and muddy or sandy substrate[1,6,7].

INTRODUCED RANGE: In Ontario, found in the Rideau River at Ottawa, the Kawartha Lakes, and the Crowe, Moira, and Trent River drainages, as well as on the shores of Lake Erie and embayments of western Lake Ontario[1,8,9,10]. Also reported in Nova Scotia, Québec, and British Columbia[1]. The species occurs widely through the United States, in Lake Erie, the drainages of Lakes Ontario and Michigan, and the Hawaiian Islands[6,11,12,13].

NATIVE RANGE: Southeast Asia to Japan, Russia[6,13].

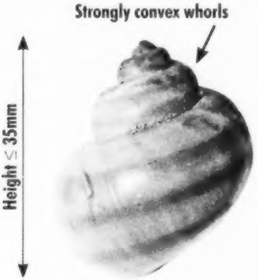
PATHWAY OF INTRODUCTION AND SPREAD: Introduced into the Great Lakes basin in the Niagara River in the 1930-40's as an aquarium release and imported as a food item for the Asian food industry[7,14]. Its spread between waterbodies may be facilitated if transported via bait buckets, live wells, bilge water, boat hulls/motors/trailers, and other equipment (e.g., fishing or scuba gear) which could potentially be contaminated with the snail.

IMPACTS: Research on impacts of the Chinese mysterysnail in North America is lacking; little is known but it has been suggested that the snail may compete with native native snail species[6].

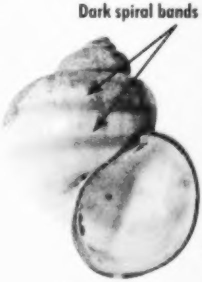
Banded Mysterysnail

Viviparus georgianus

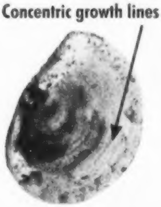
Other common name: Georgia mysterysnail



Dorsal View



Ventral View



Close-up of operculum

Photos: Gerry Mackie

DESCRIPTION: Large, banded, freshwater snail. **Size:** shell height up to 3.5 cm. **Shape:** spherical, inflated, 4-5 strongly convex whorls separated by deep sutures. Shell contains coarse and fine vertical growth lines. **Colour:** yellow to greenish brown with prominent dark-reddish spiral bands. **Operculum:** ear-shaped with concentric growth lines. **Juveniles:** young snails can be held in uterus until 3-whorl stage.[1,2,3]

SIMILAR SPECIES: Introduced Chinese mysterysnail (*Cipangopaludina chinensis*: Viv-cip-chi in this guide) is generally larger (up to 6.5 cm in height), has flatly convex whorls, and lacks prominent horizontal bands[1,4].

Introduced Japanese mysterysnail (*C. japonicus*), documented in southern Lake Erie, has no horizontal banding and looks so similar to *C. chinensis* that some consider them synonymous[5]. Native brown mysterysnail (*Campeloma decisum*) is similar in size but has a more oblong spire, a blunt or corroded terminal whorl, lower whorls that are less inflated or convex and lack spiral bands[1].

Habitat: Prefers lakes and slow-moving streams with a muddy substrate, and vegetation[1].

Introduced Range: In Ontario, found in Lakes Erie and Ontario, the Kawartha Lakes, the lower Trent-Severn, Crowe and Moira River watersheds, the lower Rideau Lakes and Ottawa River system, and the Grand River[1,6,7]. Also documented in Richelieu River and lower St. Lawrence River in Québec[1,8]. Introduced through the northeastern United States[8,9].

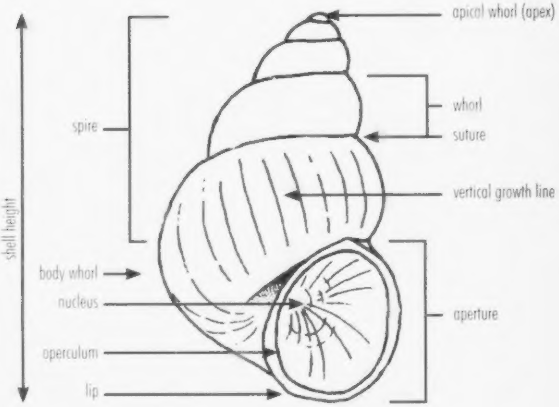
Native Range: The United States, in the Mississippi River system, north to Indiana and southward, including many southeastern states[8].

Pathway of Introduction and Spread: The earliest introduction likely was the deliberate release of snails, for unknown reasons, into New York's Hudson River watershed in the mid-1800's[8]. Deliberate or unintentional introductions may be associated with aquarium releases[8,10], while bait buckets, live wells, bilge water, boat hulls/motors/trailers, and other equipment (e.g., fishing or scuba gear), which could potentially be contaminated with snails, may help in their transport and spread between waterbodies.

Impacts: Research on impacts of the banded mysterysnail in North America is lacking. Lab and pond experiments have shown predation on largemouth bass embryos by the banded mysterysnail[11]. May compete with native snails for food and habitat.

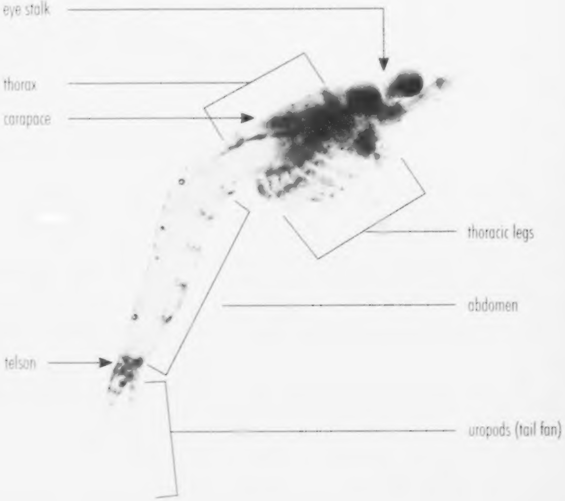
Shell of a freshwater prosobranch snail

(adapted from Clarke 1981)



Parts of a freshwater shrimp

(adapted from NOAA-GLERL 2007)



Glossary

Amphipod – any of numerous small, flat-bodied crustaceans of the group Amphipoda

Aperture – opening of a snail shell from which foot and body protrude

Apex –tip

Apical whorl – top or apex of the spire; the first formed part of snail shell

Appendage – external body part

Barb – point or pointed part projecting backward from a main point, as of a fishhook

Beak – apex or umbo of a bivalve shell; the first formed part

Carapace – the dorsal section of the exoskeleton; the hard outer covering or case of certain organisms

Caudal – at, or near the tail or the posterior end of the body

Concentric – describes the growth lines of a snail operculum that lie entirely within each other; not forming a spiral

Crustacean – any chiefly aquatic arthropod of the class Crustacea, typically having the body covered with a hard shell or crust

Distal – farthest; situated away from the point of origin or attachment

Gonopod –male sexual organ; first pair of pleopods specialized for fertilization in male crayfish (copulatory stylets)

Hinge teeth – part of the thickened part of a bivalve shell where the two halves join

Lip – structure surrounding the aperture of a snail shell

Lobe – roundish projection or division

Malleations – flattened areas, as if hammered

Nucleus – center point of growth rings in a snail operculum

Operculum – thin plate-like structure attached to the foot of a prosobranch snail that covers the aperture when the foot is withdrawn

Parthenogenic – asexual reproduction; cloning

Periostracum – hard chitinous covering on the outer shell of many molluscs

Pleopods – first of five pairs of abdominal legs or swimmerets, may be modified into male gonopod or copulatory stylets

Prosobranch – gill-breathing snail

Proximal – nearest; situated toward the point of origin or attachment

Rostrum – anterior part of carapace between eyes [ref to crayfish]

Spire – cone-shaped surface of a snail shell that tapers to a point; the whorl containing the snail body usually not considered to be part of the spire

Stylets – [copulatory stylets] pair of pleopods specialized for fertilization in male crayfish

Suture –groove marking the junction of adjacent whorls

Telson –last segment or division of the body of a crustacean; helps form the tail fan of crustaceans

Umbo – beak or apex [tip] of a bivalve mussel

Unionid – native freshwater clams of the order Unionoida, with a 'pearly' appearance on shell surface

Uropod – the three appendages that form the tail fan of a crustacean

Veliger – zooplanktonic, larval form of some molluscs, including introduced *Dreissena* mussels

Viviparous – a type of reproduction in which the young are internally maintained in uterus up until a 4-whorl stage before birth (e.g. livebearing snail)

Whorl – a single spiral turn of a snail shell

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Hobbs, H.H. III and J.P. Jass. 1988. The crayfishes and shrimp of Wisconsin (Cambaridae, Palaemonidae). Milwaukee Public Museum.

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Thorp, J.H. and A.P. Covich. 1991. Ecology and classification of North American freshwater invertebrates. Academic Press, Inc. New York.

CYPRINIDAE / Minnow and Carp Family

Goldfish

Carassius auratus

Other common names: Koi, golden carp

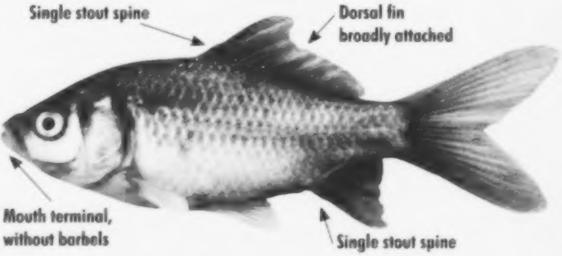


Photo: Douglas Watkinson, Fisheries and Oceans Canada

DESCRIPTION: Body: stout; lacks a keel along the midventral line; total length 127-254 mm (up to 400 mm). **Fins:** base of dorsal fin long, with 13 or more branched soft rays; first ray of dorsal and anal fins modified to form a stout spine with a serrated trailing edge; caudal fin forked. **Mouth:** small, terminal, without barbels. **Scales:** usually 26-32 in the lateral line. **Colour:** variable, from olive through orange (sometimes with black patches) to creamy white. Individuals from wild populations are mostly olive to gray in colour.[1,2,3]

SIMILAR SPECIES: The common carp (*Cyprinus carpio*: Cyp-cyp-car in this guide) has two pairs of barbels on upper jaw and usually has more than 32 scales in the lateral line[1]. The goldfish hybridizes with common carp, producing individuals of intermediate morphology[4].

HABITAT: Vegetated ponds and pools, sometimes shallow backwaters in the lower Great Lakes[1]. Can be found in lotic systems as well.

INTRODUCED RANGE: Most Ontario populations of goldfish are found in built up areas along the north shores of Lake Erie and the Golden Horseshoe[5]. It is widespread but sporadic elsewhere in the world[4].

NATIVE RANGE: Eastern and Central Asia[1].

PATHWAY OF INTRODUCTION AND SPREAD: The goldfish has been intentionally introduced for ornamental purposes to ponds, fountains and small lakes from which they may disperse through connected waters. Goldfish owners have also released their stock into public waters[4].

IMPACTS: The ecology of goldfish in North America is understudied[4]. Its varied diet includes gastropods, small insects, fish eggs and fry, which makes this species a potential competitor with, and predator of, native fishes[3,6]. When feeding on rooted vegetation, goldfish may resuspend sediments, thus increasing turbidity and inhibiting plant growth[7]. The goldfish is most successful in degraded habitats. It may not compete well within a native fish assemblage[4].

Grass Carp

Ctenopharyngodon idella

Other common names: White Amur, Amur

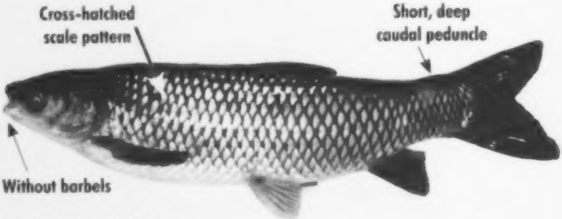


Photo: John Derkson, Lethbridge College

DESCRIPTION: Body: fusiform and moderately compressed; head broad and scaleless; caudal peduncle short and relatively deep; total length from 50-90 cm (up to 125 cm). **Mouth:** terminal to subterminal, of moderate size, without barbels. **Pharyngeal teeth:** a double row of four pointed, finely grooved or serrated teeth on each side, visible on dissection. **Fins:** spines absent; anal fin set far back; dorsal fin short with 7–9 rays. **Scales:** large with dark margins creating cross-hatched pattern, 34-47 in lateral line. **Colour:** olive-brown above blending to white below; juveniles are silvery.[1,2,3,4]

SIMILAR SPECIES: Suckers (Catostomidae) have a subterminal mouth, thick lips with folds or small, nipple-like fleshy bumps[5]. Common carp (*Cyprinus carpio*: Cyp-cyp-car in this guide) and goldfish (*Carassius auratus*: Cyp-car-aur in this guide) have a stout serrated spine in the dorsal fin and anal fin[1]. The fallfish (*Semotilus corporalis*) has a head that is not as broad, and its anal fin is set farther forward: the distance from the origin of the anal fin to the base of the caudal fin is more than 1.5 times the distance from the origin of the pelvic fin to the origin of the anal fin[6]. It resembles the black carp (*Mylopharyngodon piceus*: Cyp-myl-pic in this guide) which tends to have darker colouration and possesses a single row of four or five flat, molariform pharyngeal teeth on each side. This identification character may not be applicable to juvenile fish, <30 mm in total length[4].

HABITAT: Vegetated lakes, ponds and backwaters of rivers[7]. It tolerates low levels of dissolved oxygen and a broad range of temperatures[8].

INTRODUCED RANGE: There are fewer than ten records in Ontario from Lakes Huron, Erie, and Ontario (including the Don River)[9,10]. The grass carp was intentionally stocked for vegetation management in Alberta and Saskatchewan as it was in the United States, where it is now widespread in the upper reaches of the Mississippi watershed[11]. Also found in Europe, Africa, Australia, Indian subcontinent, Central and South America[8,12].

NATIVE RANGE: Eastern Asia, from southern Russia to northern Vietnam[8].

PATHWAY OF INTRODUCTION AND SPREAD: The source of Ontario occurrences is uncertain; however, before the possession of live grass carp was prohibited in 2005, its availability in the live food fish industry and water garden trade posed a considerable risk of accidental or unlawful release[13]. Another potential source is dispersal or transfer from the Mississippi watershed within states bordering the Great Lakes[13]. It was lawfully stocked as a food fish and to control nuisance aquatic vegetation throughout the United States where the range has increased through population growth and dispersal[11].

IMPACTS: Removal of vegetation by grass carp may eliminate food sources, shelter and spawning/nursery habitat for native invertebrates, birds and fishes. Its feeding activities may promote algal blooms, increase turbidity and alkalinity while lowering dissolved oxygen levels. The grass carp can be a vector of parasites and diseases affecting native species[8,11].

CYPRINIDAE / Minnow and Carp Family

Common Carp ***See note on 2nd page for this species***

Cyprinus carpio

Other common names: European carp, mirror carp, koi

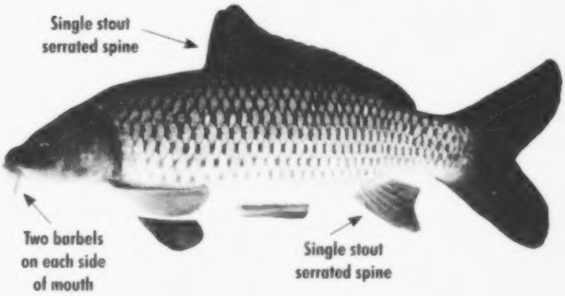

Single stout serrated spine
Two barbels on each side of mouth
Single stout serrated spine

Photo: Douglas Watkinson, Fisheries and Oceans Canada

DESCRIPTION: Body: robust and deep-bodied; total length 38-46 cm (up to 120 cm). **Mouth:** terminal on young, subterminal on adult; two pairs of barbels present. The posterior pair at the corners of the mouth are the more conspicuous. **Fins:** dorsal fin base long with 17-21 soft rays. Dorsal and anal fins each have a single, stout spine with a serrated trailing edge. **Scales:** thick and large, 35-39 in the lateral line. Some uncommon morphs, *i.e.*, leather carp and mirror carp, have much reduced scalation. **Colour:** usually olive-grey on back lightening to white or yellow on the belly.[1,2]

SIMILAR SPECIES: The goldfish (*Carassius auratus*: Cyp-car-aur in this guide) lacks barbels and usually has fewer than 32 scales in the lateral line[1]. Grass carp (*Ctenopharyngodon idella*: Cyp-cte-ide in this guide) lacks barbels, has a short dorsal fin without a spine, fusiform body shape, and eyes set low on the sides of the head[3,4].

HABITAT: Found in low gradient streams, reservoirs and lakes, commonly in waters with high levels of organic matter, the common carp forages over a variety of bottoms and may thrive in highly eutrophic, disturbed habitats unsuitable for many native species[1].

INTRODUCED RANGE: In Ontario, the common carp is well established in the Great Lakes basin and connected waterways, most abundantly in the south[5]. It has been introduced throughout the Americas, Africa, the Middle East and Australia[1,6].

NATIVE RANGE: Temperate Eurasia[1].

PATHWAY OF INTRODUCTION AND SPREAD: The common carp was introduced widely as a food fish in Canada, where population growth and dispersal increased its geographic range[1]. Colourful varieties (nishikigoi or koi) from garden ponds have also been introduced to public waters in many countries[7]. In the United States, it has been sold as a baitfish[8]. Because juvenile common carp may be superficially similar in appearance to, and potentially mistaken for, some Ontario baitfish species, it may be unintentionally spread through the use of live bait.

IMPACTS: Because its establishment predates many of the earliest fish surveys, the impact of common carp upon native fish assemblages in Ontario is difficult to assess[1]. In other regions, substantial and varied negative impacts have been documented. Feeding activity uproots aquatic plants, reducing food and breeding habitat for native invertebrates, birds and fishes[9]. The associated disturbance of bottom sediments may increase turbidity and further inhibit plant growth. Larval carp may compete with native fish species for zooplankton[9]. Adults compete with native fishes for benthic invertebrate prey. Predation on eggs of native fishes may adversely impact prey populations[9].

***NOTE - We are not seeking reports on common carp: This information sheet has been included to help you differentiate common carp from similar-looking species of carp in the guide, e.g., grass carp (Cyp-cte-ide) and goldfish (Cyp-car-aur) which should be reported as per section 3.0 REPORTING PROCEDURE.**

Silver Carp

Hypophthalmichthys molitrix

Other common name: None

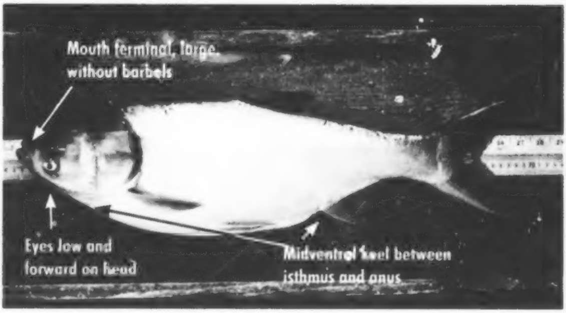

Mouth terminal, large, without barbels
Eyes low and forward on head
Midventral keel between isthmus and anus

Photo: David Riecks, Great Lakes Sea Grant Network Exotic Species Library

DESCRIPTION: Body: fusiform, broad, moderately compressed with a moderately long caudal peduncle; a smooth midventral keel runs from the anus to the isthmus; total length 40-70 cm (up to 130 cm). **Mouth:** terminal, disproportionately large, without barbels; lower jaw slightly longer than the upper one. **Eyes:** positioned ventrally, forward on the head. **Fins:** dorsal fin short, lacking spines, with 7–10 rays, originating behind the origin of the pelvic fins. **Scales:** very small, 91-124 along a ventrally curved lateral line. **Colour:** olive to grayish black on back with silvery sides blending to white below, with fins showing darker pigmentation.[1,2]

SIMILAR SPECIES: Suckers (Catostomidae) have thick lips with folds or small, nipple-like fleshy bumps[3]. Common carp (*Cyprinus carpio*: Cyp-cyp-car in this guide) and goldfish (*Carassius auratus*: Cyp-car-aur in this guide) have a stout serrated spine in the dorsal fin and anal fin[4]. The golden shiner (*Notemigonus crysoleucas*) and rudd (*Scardinus erythropthalmus*: Cyp-sca-ery in this guide) possess a midventral keel but have larger scales numbering fewer than 60 in the lateral line[5]. The silver carp closely resembles the bighead carp (*Hypophthalmichthys nobilis*: Cyp-hyp-nob in this guide), which differs in having a midventral keel that is less extensive, running from the anus to the pelvic fins and has dark blotches on the body[1].

HABITAT: Large river systems, lakes and impoundments from temperate to subtropical climates. Has been reported feeding at temperatures as low as 2.5°C[6]. Often swims near the surface. It can withstand low levels of oxygen[2].

INTRODUCED RANGE: Not yet recorded in Ontario[7,8]. Documented from open waters of the Mississippi, Missouri and Ohio watersheds in the United States. In 2002, an electric barrier was installed in the Chicago Sanitary and Ship Canal to prevent the dispersal of this and other species between the Mississippi and Great Lakes watersheds[9]. Also found in Central America, Cuba, India and Japan[10].

NATIVE RANGE: Lowland rivers of eastern China and Russia[2,9].

PATHWAY OF INTRODUCTION AND SPREAD: Before the possession of live silver carp was prohibited in Ontario in 2005, its availability in the live food fish industry posed a considerable risk of accidental or unlawful release[11]. Another potential source is dispersal or transfer from the Mississippi watershed within states bordering the Great Lakes[9]. In the United States, it has become established following escape from freshwater aquaculture facilities where it is used to control phytoplankton blooms. Because the juvenile silver carp is similar in appearance to, and may be mistaken for, some baitfish species, it may be unintentionally spread through the use of live bait.

IMPACTS: The ecology of silver carp in its introduced North American range remains largely unstudied. As it feeds primarily on phytoplankton, and secondarily on zooplankton, it may compete for food with native fishes and filter-feeding invertebrates, with wider effects on food web and trophic structure[2,9]. When disturbed, silver carp frequently leaps clear of the water, posing a risk of harm to boaters[2]. It may also be a vector for parasites and diseases affecting native species[11].

Bighead Carp

Hypophthalmichthys nobilis

Other common name: None

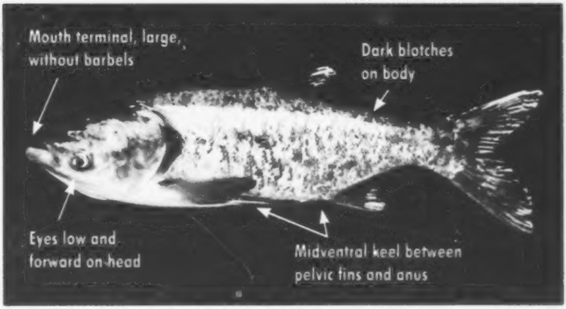

Mouth terminal, large, without barbels
Dark blotches on body
Eyes low and forward on head
Midventral keel between pelvic fins and anus

Photo: David Riecks, Great Lakes Sea Grant Network Exotic Species Library

DESCRIPTION: Body: fusiform, broad and moderately compressed with a moderately long caudal peduncle; a smooth midventral keel runs from the anus to the pelvic fins; total length 40-70 cm (up to 130 cm). **Mouth:** terminal, disproportionately large, without barbels, lower jaw slightly longer than the upper one. **Eyes:** positioned ventrally, forward on the head. **Fins:** dorsal fin short, lacking spines, with 7–10 rays, originating behind the origin of the pelvic fins; males possess a sharp-edged bony margin to the dorsal surface of several anterior pectoral fin rays. **Scales:** very small, 91-120 along a ventrally curved lateral line. **Colour:** solid grey on back blending to white below, with numerous, irregular grayish-black blotches.[1,2]

SIMILAR SPECIES: Suckers (Catostomidae) have a subterminal mouth, thick lips with folds or small, nipple-like fleshy bumps[3]. Common carp (*Cyprinus carpio*: Cyp-cyp-car in this guide) and goldfish (*Carassius auratus*: Cyp-car-aur in this guide) have a stout serrated spine in the dorsal fin and anal fin[4]. The golden shiner (*Notemigonus crysoleucas*) and rudd (*Scardinus erythropthalmus*: Cyp-sca-ery in this guide) possess a midventral keel but have larger scales numbering fewer than 60 in the lateral line[5]. Very closely resembles the silver carp (*Hypophthalmichthys molitrix*: Cyp-hyp-mol in this guide) which differs in having a midventral keel that is more extensive, running from the anus to the isthmus. Silver carp also lacks dark blotches on the body[1].

HABITAT: Large river systems and lakes from temperate to subtropical climates[6]. Often swims near the surface. Can withstand low levels of oxygen[2].

INTRODUCED RANGE: In Ontario, there have been three occurrences documented from 2000 through 2003, all in western Lake Erie[7]. In 2002, an electric barrier was installed in the Chicago Sanitary and Ship Canal to prevent the dispersal of this and other species between the Mississippi and Great Lakes watersheds[6]. Recorded in open waters of the Mississippi watershed in the United States, and also in Central America, Cuba, India, and Japan[8].

NATIVE RANGE: Eastern Asia in China and far eastern Russia[6].

PATHWAY OF INTRODUCTION AND SPREAD: Before the possession of live bighead carp was prohibited in Ontario in 2005, its availability in the live food fish industry posed a considerable risk of accidental or unlawful release[7]. Another potential source is dispersal or transfer from the Mississippi watershed within states bordering the Great Lakes[6]. In the United States, it has become established following escape from freshwater aquaculture facilities where it is raised for food or used to control phytoplankton blooms. Because the juvenile bighead carp is similar in appearance to, and may be mistaken for, some baitfish species, it may be unintentionally spread through the use of live bait.

IMPACTS: The ecology of bighead carp in its introduced North American range remains largely unstudied. As it is a large bodied fish feeding primarily on zooplankton, and secondarily on phytoplankton, it may compete for food with native fishes and filter-feeding invertebrates, with wider effects on food web and trophic structure[2,6]. It may be a vector for parasites and diseases affecting native species[7].

CYPRINIDAE / Minnow and Carp Family

Black Carp

Mylopharyngodon piceus

Other common names: Black Amur, snail carp

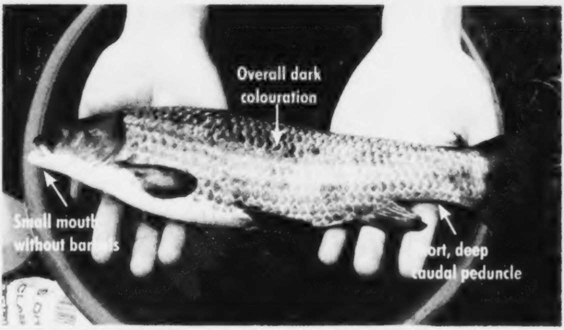


Photo: Black Carp (261 millimeter SL) from the species' native range in the Chang (Yangtze) River Basin, Hunan Province, People's Repbulic of China. (Collected by C. Zhang, F. Fang, and colleagues during trip financed by the European Commission, INCO-DEV program, project ECOCARP, contract number ICA4-CT-2001-10024. Photography courtesy of Fang Fang Kullander, Swedish Museum of Natural Histroy, Stockholm.)

DESCRIPTION: Body: stout and fusiform, cylindrical to slightly compressed; caudal peduncle short and relatively deep; total body length may reach 200 cm. **Mouth:** terminal to slightly subterminal, of small to moderate size, without barbels. **Pharyngeal teeth:** a single row of four or five large, flat, molariform teeth on each side, visible on dissection. **Fins:** spines absent; anal fin set far back; dorsal fin short with 7–9 rays; caudal fin large and forked. **Scales:** moderately large, 39-46 in the lateral line. **Colour:** variable, dark brown to black on back and sides, some white on underside, fins dark.[1]

SIMILAR SPECIES: Suckers (Catostomidae) have a subterminal mouth, thick lips with folds or small, nipple-like fleshy bumps[2]. Common carp (*Cyprinus carpio*: Cyp-cyp-car in this guide) and goldfish (*Carassius auratus*: Cyp-car-aur in this guide) have a stout serrated spine in the dorsal fin and anal fin[3]. The fallfish (*Semotilus corporalis*) has a head that is not as broad, and its anal fin is set farther forward: the distance from the origin of the anal fin to the base of the caudal fin is more than 1.5 times the distance from the origin of the pelvic fin to the origin of the anal fin[2]. Resembles the grass carp (*Ctenopharyngodon idella:* Cyp-cte-ide in this guide), which tends to be lighter in colouration and possesses two rows of long, finely grooved pharyngeal teeth on each side. This identification character may not be applicable to juvenile fish (< 30 mm total length)[1].

HABITAT: Large river systems and embayments, in temperate to sub-tropical climates[4]. Found lower in the water column than other Asian carps and at a wide range of depths[5].

INTRODUCED RANGE: Not recorded from the wild in Ontario[5,6,7]. Recorded in open waters of the Mississippi River and Red River watersheds in the United States; also found in Mexico, Cuba, Europe and Japan[4].

NATIVE RANGE: Far eastern Asia from southern Russia to northern China[4].

PATHWAY OF INTRODUCTION AND SPREAD: Before the possession of live black carp was prohibited in Ontario in 2005, its availability in the live food fish industry posed a considerable risk of accidental or unlawful release[5]. There is some possibility that records of this species in Toronto markets are based on the misidentification of other species[5]. Another potential source is dispersal or transfer from the Mississippi watershed within states bordering the Great Lakes[5]. In the United States, it has escaped from freshwater aquaculture facilities where it is raised for food or is introduced for the control of disease-carrying snails[4].

IMPACTS: As a dedicated molluscivore, this species poses a considerable threat to native snails and mussels in the Great Lakes basin, a high proportion of which are already at risk[4]. It may be a vector for parasites and diseases affecting native species[4,5].

CYPRINIDAE / Minnow and Carp Family

Rudd

Scardinus erythropthalmus

Other common name: None

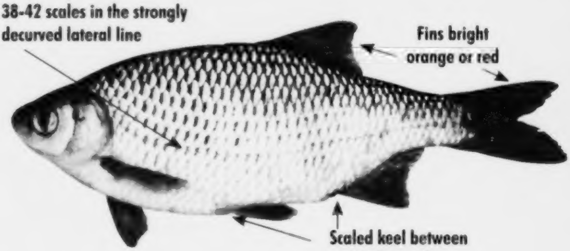

38-42 scales in the strongly decurved lateral line
Fins bright orange or red
Scaled keel between pelvic fins and anus

Photo: John Lyons, Wisconsin Department of Natural Resources

DESCRIPTION: Body: robust, laterally compressed and elliptical in profile; scaled keel between pelvic fins and anus; lateral line strongly decurved; total length 100-250 mm (up to 360 mm). **Mouth:** terminal and oblique, without barbels. **Eyes:** iris yellow to orange, often with red spot over pupil. **Scales:** anterior radii present; lateral line count 38-42. **Colour:** brown-green above, brassy yellow to rosy sides, fins bright orange or red. [1,2,3]

SIMILAR SPECIES: The juvenile rudd closely resembles the golden shiner (*Notemigonus crysoleucas*) which differs in the following characters: fins clear to pale orange (usually yellow), not bright orange or red[4], lateral line scales 44-54; anterior radii on scales absent; midventral line keeled and not scaled; red spot on the iris above pupil absent[2].

HABITAT: The rudd is most often found in still or sluggish, often vegetated water but it can inhabit a variety of freshwater habitats[3]. Commonly occurs in the upper portion of the water column[5] and may thrive in degraded habitats unsuitable for native species[6].

INTRODUCED RANGE: Since the rudd was first detected in Ontario in 1990, there have been scattered occurrences from the lower Great Lakes and one inland record on Wilcox Lake, Humber River watershed, north of Toronto[7,8]. It is widely established in United States[6].

NATIVE RANGE: Western Europe to the Caspian and Aral Sea basins[6].

PATHWAY OF INTRODUCTION AND SPREAD: The Ontario occurrences of the rudd were likely derived from populations in New York State, where, as elsewhere in the United States, it has been introduced for sport and food and is cultured and sold as a baitfish[2]. The source of many introduced populations is unknown; however, in some instances, the founders are presumed to have dispersed far from the point of original release[6]. Because rudd may be superficially similar in appearance to, and potentially mistaken for, some baitfish species, it may be unintentionally spread through the use of live bait.

IMPACTS: Largely unknown and unstudied in North America. The rudd may compete with native fishes for invertebrate food sources[6]. By feeding on macrophytes, it may alter the structure and composition of spawning and nursery sites utilized by native fishes. It has been suggested that genetic compatibility between the rudd and the golden shiner poses a threat to the genetic integrity of the latter species[9].

CYPRINIDAE / Minnow and Carp Family

Tench

Tinca tinca

Other common name: None

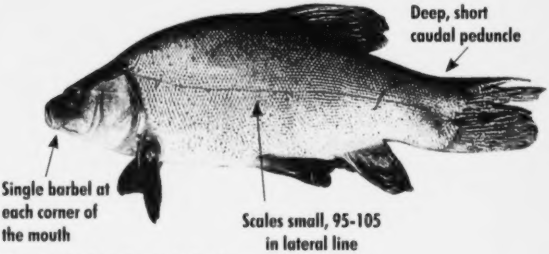

Deep, short caudal peduncle
Single barbel at each corner of the mouth
Scales small, 95-105 in lateral line

Photo: Mark Malchoff, Lake Champlain Sea Grant Project

DESCRIPTION: Body: deep and moderately laterally compressed; caudal peduncle is deep and short; total length 203-254 mm (up to 840 mm). **Mouth:** terminal, a single, slender barbel at the corner of the mouth, on each side of the head. **Fins:** dark and rounded, without spines. **Scales:** characteristically small, numbering from 95-105 along the lateral line. **Colour:** dark olive to pale golden tan above, white to bronze below with a bright reddish-orange eye.[1,2,3]

SIMILAR SPECIES: Superficially resembles other native and introduced cyprinids but can be distinguished by the deep body, high lateral line scale count and the single barbel at each corner of the mouth[3].

HABITAT: The tench inhabits lakes and slow-moving, weedy waterways with muddy substrates. It can tolerate low levels of dissolved oxygen and a broad temperature range from near freezing to 24°C[1,4].

INTRODUCED RANGE: The tench is not yet known from Ontario[5,6]. The range in Canada is limited to the Columbia watershed in British Columbia[7] and the Richelieu River in Québec[4]. It is well established in the United States, particularly in the Mississippi watershed.

It has also been introduced to Australia, Africa and South America[7].

NATIVE RANGE: Europe and western Asia[1].

PATHWAY OF INTRODUCTION AND SPREAD: The tench has been lawfully introduced for food and sport across the United States[7]. An unlawful release in Québec following an aquaculture trial has led to its establishment in the Richelieu River, a tributary of the St. Lawrence River from which it may enter Ontario[4]. Another potential path of entry to Ontario is through dispersal or transfer from the Mississippi watershed within states bordering the Great Lakes. Because tench may be superficially similar in appearance to, and potentially mistaken for, some baitfish species, it may be unintentionally spread through the use of live bait.

IMPACTS: Direct impacts on other fish have not been documented; however, it is a potential competitor with minnows, bullheads and suckers for prey including gastropods and insect larvae[4]. Selective predation upon grazing snails may result in increased algal biomass and the feeding behaviour may stir up sediments, leading to decreased water clarity[7].

GASTEROSTEIDAE / Stickleback Family

Fourspine Stickleback

Apeltes quadracus

Other common names: Stickleback, pinfish, mud-pouch, mud-perch, bloody stickleback

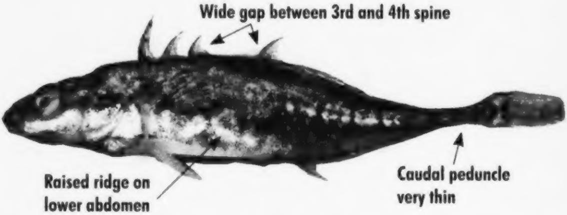

Wide gap between 3rd and 4th spine
Raised ridge on lower abdomen
Caudal peduncle very thin

Photo: Mark Gautreau, Canadian Rivers Institute, University of New Brunswick

Description: **Body**: fusiform, compressed laterally; caudal peduncle very thin, without a lateral keel; ridge on both sides of the lower abdomen behind pectoral fins; total length 51-64 mm (up to 70 mm). **Mouth**: terminal, small, lower jaw projecting slightly. **Fins/spines**: four dorsal spines, inclined alternately to left and right, of graduated size (decreasing towards posterior) with the first three close together followed by a wide gap between the third and the fourth, which is attached to a soft dorsal fin with 10-13 soft rays; pelvic fin modified to form one serrated spine with two soft rays. **Scales/plates**: none. **Colour**: olive-green to brown on back, dark, mottled brown sides and silvery-white on belly; males may be all black; breeding male has red pelvic fins.[1,2,3,4]

Similar Species: The brook stickleback (*Culaea inconstans*) has four to six (usually five) free dorsal spines of similar length, typically less than eye diameter. The threespine stickleback (*Gasterosteus aculeatus*: Gas-gas-acu in this guide) has two to four (usually three) free dorsal spines, the first inserted over the pectoral base, the first two substantially larger than the third, or fourth, if present; caudal peduncle usually with a lateral keel[1,5,6].

HABITAT: Shallow, brackish estuarial waters and, less frequently, fresh water streams and lakes[1]. In its introduced range in Lake Superior, it is found in heavily vegetated shallows[7].

INTRODUCED RANGE: In Ontario, the fourspine stickleback is found in Lake Superior, from Thunder Bay east to the mouth of the Black River[7,8]. In the United States, it is established in Pennsylvania, New Jersey and Alabama[9].

NATIVE RANGE: Coastal areas of eastern North America from the Gulf of St. Lawrence to Virginia[1].

PATHWAY OF INTRODUCTION AND SPREAD: Its detection in Lake Superior in 1986 is thought to have followed an introduction from ballast water transport. Bait bucket transfers pose the risk of further spread[7].

IMPACTS: The fourspine stickleback may compete with other species for invertebrate prey. It may also prey upon the eggs and larvae of other fishes in the nearshore habitats preferred by this species. Populations of native sticklebacks declined following the establishment of this species in Lake Superior[7].

Threespine Stickleback

Gasterosteus aculeatus

Other common names: Twospine stickleback, banstickle, spanstickle, saw-finned stickleback, eastern stickleback

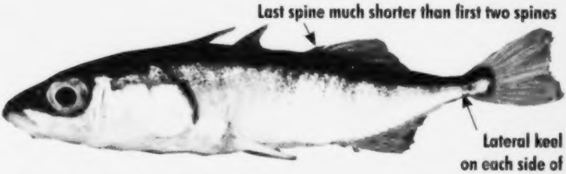

Last spine much shorter than first two spines
Lateral keel on each side of caudal peduncle

Photo: John Lyons, Wisconsin Department of Natural Resources

Description: Body: fusiform, compressed laterally; narrow caudal peduncle usually with a lateral keel; total length 35-65 mm (up to 100 mm). **Mouth:** small, terminal and slightly oblique. **Fins/spines:** two to four (usually three) free dorsal spines, the first inserted over the pectoral base, the first two substantially larger than the third, or fourth, if present; soft dorsal fin with 9-11 connected rays; pelvic fin modified to form one spine with a single pointed cusp and one soft ray. **Scales/plates:** lacks scales and may have up to 30 small bony plates on the sides; native Lake Ontario form partially plated. **Colour:** green to brownish above with some darker markings, shading to silvery below; breeding males are bright red on lower sides and belly.[1,2,3,4,5]

Similar Species: The brook stickleback (*Culaea inconstans*) has four to six (usually five) free dorsal spines of similar length, typically less than eye diameter and is without lateral keels on the caudal peduncle. The fourspine stickleback (*Apeltes quadracus*: Gas-ape-qua in this guide) usually has four dorsal spines, inclined alternately to left and right, of graduated size (decreasing towards posterior) with the first three being close together followed by a wide gap between the third and the fourth[1,2].

HABITAT: Varied - common in shallow weedy areas in rivers, streams, lakes and ponds as well as pelagic and deep-water (up to 50 m) habitats[1,2,6]. It also occurs in brackish and marine waters[1].

INTRODUCED RANGE: In Ontario, the threespine stickleback is established in Lakes Erie, Huron, Superior and connecting waterways[6,7]; also found in inland waters of California and parts of Europe[8].

NATIVE RANGE: In Ontario, from Niagara Falls, through Lake Ontario and the St. Lawrence and Ottawa Rivers, and the Hudson Bay Lowland. Widely distributed throughout the northern hemisphere, in North America along the west and east coasts south to Baja California and Virginia, respectively; also in Europe, Greenland and the Pacific coast of Asia[1,3].

PATHWAY OF INTRODUCTION AND SPREAD: In the Great Lakes, the species was first detected beyond Lake Ontario (where it is native) in Lakes Huron, Michigan, Superior, and Erie from the years 1980 to 1988[6]. These introductions are thought to have resulted from both ballast water and bait bucket transfers[5,6].

IMPACTS: Populations of native sticklebacks declined following the establishment of this species in Lake Superior[6]. Hybridization between native and introduced forms may be occurring in Lake Ontario, with unknown consequences. It may compete with other species for invertebrate prey and it may prey upon the eggs and larvae of other fishes[8].

GOBIIDAE / Goby Family

Round Goby

Neogobius melanostomus

Other common name: None

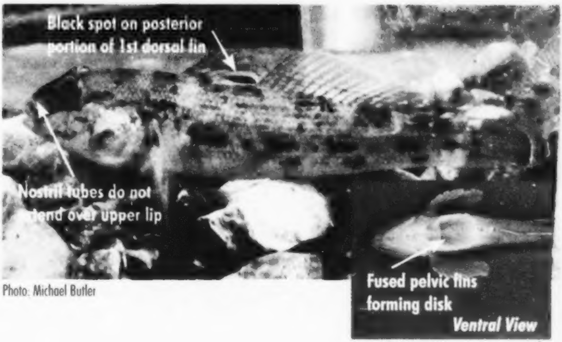

Black spot on posterior portion of 1st dorsal fin
Nostril tubes do not extend over upper lip
Fused pelvic fins forming disk
Ventral View

Photo: Michael Butler

Inset: John Lyons, Wisconsin Department of Natural Resources

Description: Body: cylindrical, snout rounded to blunt; total length 60-160 mm (up to 250 mm). **Mouth:** wide, terminal to slightly subterminal; lips large, without barbels; nostril tubes do not reach upper lip. **Fins:** first dorsal with 5-7 spines; second dorsal long with one spine followed by 13-16 soft rays; the pelvic fins are fused to form a suctorial disk; anal fin has one spine and 11-14 soft rays; caudal fin rounded. **Scales:** small, covering the top of the head, behind the eyes, and body, 45-57 along midline (without lateral line). **Colour:** back and sides mottled black, brown, or gray on a lighter brown, olive, or gray background, cream to white below; characteristic black spot, larger than the eye, on the rear of the first dorsal fin, although this feature is not apparent on some specimens. During spawning and nest guarding, males are black with yellow spots on the body.[1,2,3,4,5]

Similar Species: The tubenose goby (*Proterorhinus marmoratus*: Gob-pro-mar in this guide) differs in having elongated nostril tubes extending over the upper lip and is without a black spot on first dorsal fin. Native sculpins

(*Cottus* spp. and *Myoxocephalus thompsonii*) are without scales and usually without a black spot on the first dorsal fin; pelvic fins are separate and do not form a suctorial disk[1,4].

HABITAT: Cobble, gravel and sandy substrates, with or without vegetation, in nearshore and deep waters, in lakes and the middle and lower reaches of rivers[2]. It can withstand low levels of dissolved oxygen[3].

INTRODUCED RANGE: In Ontario, found in all Great Lakes, as well as the Trent River, Rice Lake, and Lake Simcoe in the Trent-Severn Waterway[6,7]. Also in western Europe[2].

NATIVE RANGE: Black and Caspian Sea basins[2].

PATHWAY OF INTRODUCTION AND SPREAD: Introduced from Europe in ballast water. All Great Lakes were invaded in a short time span following the initial discovery in the St. Clair River in 1990. This suggests that inter- and intra-lake transfers via ballast water, along with population growth and dispersal, have facilitated its spread. The diel vertical migration of round goby larvae may also have contributed to their rapid dispersal[8]. It is illegal to possess the round goby in Ontario; however, because round goby has the potential to be mistaken for some baitfish species, it may be unintentionally spread through the use of live bait.

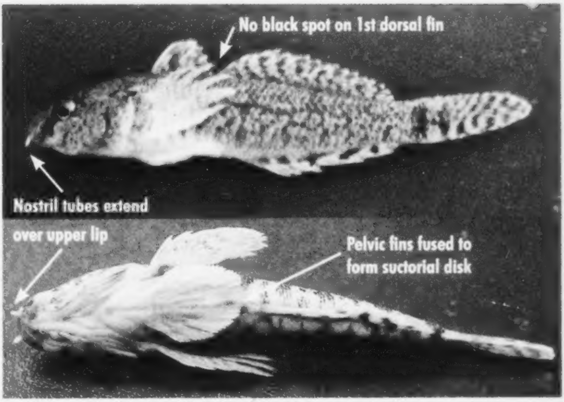
IMPACTS: The round goby competes with, and/or preys upon, native benthic fishes including mottled sculpin (*Cottus bairdii*) and logperch (*Percina caprodes*)[9,10] and threatens at least a dozen already imperiled fish species in the Lake Erie basin[11]. The round goby also eats fish eggs and larvae and so may pose a threat to stocks of game fish[12]. It has been shown to alter energy, contaminant, and nutrient pathways in the Great Lakes[13].

GOBIIDAE / Goby Family

Tubenose Goby

Proterorhinus marmoratus

Other common name: None


No black spot on 1st dorsal fin
Nostril tubes extend over upper lip
Pelvic fins fused to form suctorial disk

Photos: Top - John Lyons, Wisconsin Department of Natural Resources; Bottom - Lynda Corkum, University of Windsor

Description: Body: cylindrical but somewhat flattened on ventral surface; snout rounded to blunt; total length 60-110 mm (up to 115 mm). **Mouth:** wide, slightly subterminal; lips large, without barbels; nostril tubes extend over the upper lip. **Fins:** first dorsal with 7-8 spines; second dorsal long with one spine followed by 14-18 soft rays; pelvic fins are fused to form a suctorial disk; anal fin has one spine and 12-15 soft rays; caudal fin rounded. **Scales:** small, covering the top of the head, behind the eyes, and body, 45-48 along midline (without a lateral line). **Colour:** back and sides with dark, broad, oblique blotches on a lighter brown, olive, or tan background; cream to white below; prominent oblique black lines on dorsal fins; a triangular black spot, bordered by two white spots at the base of the caudal fin.[1,2,3,4,5]

Similar Species: The round goby (*Neogobius melanostomus*: Gob-neo-mel in this guide) differs in having nostril tubes which do not reach over the upper lip. The round goby often has a black spot on the posterior portion of the first dorsal fin. Native sculpins (*Cottus* spp.

and *Myoxocephalus thompsonii*) are without scales and the pelvic fins are separate and do not form a suctorial disk[2,4].

HABITAT: Inshore areas with plant cover in lakes and rivers[3]. In the Detroit River, tubenose gobies were positively associated with complex macrophytes in the fall, and strongly negatively associated with complex macrophytes in the spring and summer[6]. It can withstand low levels of dissolved oxygen[3].

INTRODUCED RANGE: In Ontario, from the St. Clair River to Lake St. Clair and Lake Erie[7,8]. In Lake Superior, recorded from Duluth Harbor, Minnesota[9]. Also found in central Europe[3].

NATIVE RANGE: Black and Caspian Sea basins[3].

PATHWAY OF INTRODUCTION AND SPREAD: First detected in the St. Clair River in 1990[3], it was introduced from eastern Europe in ballast water[10]. It is illegal to possess tubenose goby in Ontario; however, there is a possibility that it may be unintentionally spread through the use of live bait. Inter- and intra-lake transfers via ballast water may result in further spread. This species has not dispersed as widely or reached the densities documented for round goby[11].

IMPACTS: While the impacts are not yet known, the tubenose goby may compete with, and prey upon, native benthic fishes in a manner similar to that documented for the larger round goby[11,12]. It may also impact, through predation and competition, non-benthic fish species that utilize the tubenose goby's preferred littoral zone habitat as sites for spawning and nurseries.

MORONIDAE / Striped Bass Family

White Perch

Morone americana

Other common names: Narrow-mouthed bass, silver perch, perch, bass, sea perch

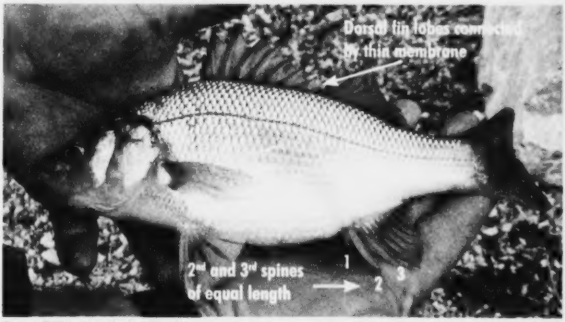

Dorsal fin lobes connected by thin membrane
2nd and 3rd spines of equal length
1
2
3

Photo: Jeff White, St. Michael's College, Vermont

Description: Body: laterally compressed and deep, deepest under the first dorsal fin, steeply sloped from the dorsal origin to the eye; total length 127-178 mm (up to 300 mm). **Mouth:** terminal and moderately large, extending to below the eye. **Fins:** spiny and soft-rayed dorsal fins joined at base by a small membrane; anal fin with 8-10 soft rays preceded by three stout anal spines, not graduated in length, the second and third are of approximately equal length. **Colour:** from grayish green to dark green-brown above, paler on sides and silvery-white below.[1,2,3]

Similar Species: The white bass (*Morone chrysops*) grows larger and is more uniformly silver, usually with prominent dark horizontal stripes, anal fin with 12-13 soft rays, anal spines graduated in length, and the first and second dorsal fins not joined by a small membrane[1]. Hybridization, producing blended characters has been documented in Lake Erie[4].

Habitat: The white perch thrives in brackish and freshwaters that exceed 23°C in summer. Exploits shallow and deep waters[1].

Mor-mor-ame

Introduced Range: In Ontario, the Great Lakes (excluding Lake Superior) as well as the Thames, St. Clair and Detroit Rivers. It is not yet known from the Trent-Severn or Rideau Waterways[5]. In the United States, white perch has become established in numerous states in the Mississippi watershed[6].

Native Range: Atlantic coastline of North America including lower St. Lawrence River south to South Carolina[1].

Pathway of Introduction and Spread: The white perch entered the lower Great Lakes via the Erie Barge and Welland Canals in the early 1950's and spread westward[1]. It is widely stocked as a sport fish throughout much of the Mississippi River watershed in the United States[6].

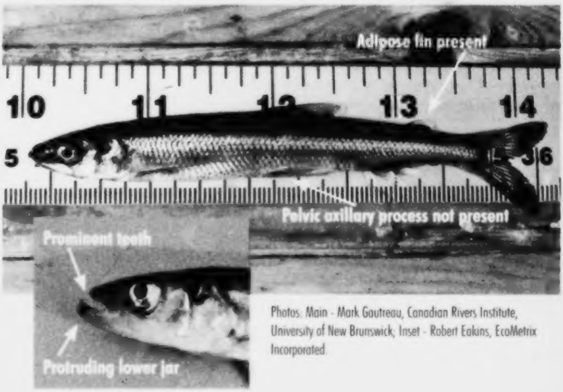
Impacts: The diet includes zooplankton, insect larvae and fishes and so the white perch may compete with native game and forage fishes[6]. In spring, fish eggs are a major food source[7] and this may limit the recruitment of walleye. In the Bay of Quinte, Lake Ontario, the establishment of large populations of white perch coincided with the decline of yellow perch and walleye stocks[7]. Hybridization with native white bass may degrade the gene pool of that species[4].

OSMERIDAE / Smelt Family

Rainbow Smelt

Osmerus mordax

Other common names: Smelt, American smelt, freshwater smelt, leefish



Photos: Main - Mark Gautreau, Canadian Rivers Institute, University of New Brunswick; Inset - Robert Eakins, EcoMetrix Incorporated.

DESCRIPTION: Body: elongate, compressed laterally, deepest anterior to dorsal fin origin; total length 178-203 mm (up to 350 mm). **Mouth:** terminal, large, without barbels, with prominent teeth on the tongue and the roof of mouth; lower jaw protruding. **Fins:** without spines; single dorsal fin with 8-11 soft rays; caudal fin forked; anal fin with low profile and long base, 12-16 soft rays; adipose fin present. **Scales:** thin and easily detached, 62-72 pored scales in an incomplete lateral line. **Colour:** black to olive-tan back, silvery sides with iridescent blue, purple and pink hues, and whitish belly; head and posterior edge of tail darkly pigmented.[1,2,3,4]

SIMILAR SPECIES: Superficially similar minnow species lack an adipose fin and prominent teeth. In salmonids, including trout, salmon, lake herring and whitefish, the lateral line is complete and a pelvic axillary process is present[1,3,4].

HABITAT: Clear lakes, rivers and coastal waters, often schooling in open water and spawning in streams[1,2].

INTRODUCED RANGE: In Ontario, found in all of the Great Lakes, the Trent-Severn Waterway from Lake Simcoe to Port Severn as well as Stony Lake, many Muskoka and Parry Sound area lakes, the Ottawa River and Lake Nipissing. In northwest Ontario, found in the Lake Nipigon basin and in the Rainy and English-Wabigoon River systems including Lake of the Woods[5,6]. In the United States, established in the northeast as well as parts of the Colorado, Missouri, Mississippi and Tennessee River drainages[7].

NATIVE RANGE: In eastern North America, Atlantic coastal drainages from Labrador to New Jersey, as well as landlocked waters in Québec, the Maritime Provinces and New England states. Also found in Pacific drainages of North America and Asia[1,2].

PATHWAY OF INTRODUCTION AND SPREAD: Populations in Lake Erie and the upper Great Lakes are derived from deliberate stocking in Michigan in the early 1900's[1]. The rainbow smelt likely invaded Lake Ontario from inland populations in New York State[8]. Its spread may be abetted by inter- and intra-lake transport in ballast water. Population growth, dispersal and bait bucket transfers resulted in further spread in Canada[1,5]. Another possible vector is through the improper disposal of fish remains, containing gametes, following the harvest of ripe fish during the spring spawning run[9]. In the United States, this species has been introduced as forage and sold as bait for game fishes[7].

IMPACTS: Native fish species are impacted, sometimes extirpated, through competition with, and/or predation by, rainbow smelt. Affected species include yellow perch (*Perca flavescens*), walleye (*Sander vitreus*), lake herring (*Coregonus artedi*), bloater (*C. hoyi*), whitefish (*C. clupeaformis*), lake trout (*Salvelinus namaycush*), and slimy sculpin (*Cottus cognatus*)[9,10]. Invasive rainbow smelt may disrupt food webs and induce significant changes in zooplankton communities[11].

PERCIDAE / Perch Family

Ruffe

Gymnocephalus cernuus

Other common names: Eurasian ruffe, blacktail, redfin darter, river ruffe

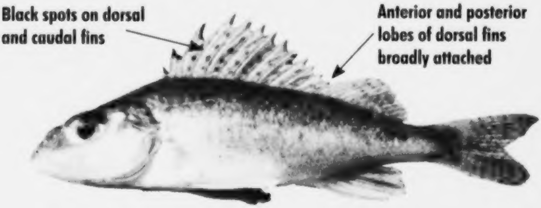

Black spots on dorsal and caudal fins
Anterior and posterior lobes of dorsal fins broadly attached

Photo: John Lyons, Wisconsin Department of Natural Resources

DESCRIPTION: Body: fusiform, fairly deep and compressed; total length 110-150 mm (up to 250 mm). **Fins:** long anterior lobe of dorsal fin with 11-18 spines broadly attached by a membrane to a posterior soft lobe with one spine and 11-16 soft rays. **Head:** unscaled. **Mouth:** terminal to slightly subterminal. **Colour:** green-brown above, dark patches on light brown sides, yellowish below, black spots on dorsal and caudal fins.[1,2,3]

SIMILAR SPECIES: Yellow perch (*Perca flavescens*) has two separate dorsal fins and a body pattern with dark vertical bars. The trout-perch (*Percopsis omiscomaycus*) has a short, single-lobed dorsal fin, and an adipose fin is present[2].

HABITAT: Highly adaptable - exploits a very wide range of depths and conditions in lakes and rivers. Spawns between 4.9° and 20°C[4].

INTRODUCED RANGE: In Ontario, the ruffe has been recorded from Thunder Bay, Lake Superior[5,6]. In the United States it is found in Lakes Superior, Michigan and Huron[7]. It has been introduced to the United Kingdom[8].

NATIVE RANGE: Northern Europe and Asia[1].

PATHWAY OF INTRODUCTION AND SPREAD: The ruffe was transported to North America in the ballast water of vessels arriving from Europe before 1996, when it was first detected in Duluth Harbour, in Lake Superior[8]. It may spread further through ballast water exchange within the Great Lakes[8]. It is illegal to possess ruffe in Ontario; however, there is a possibility that it may be unintentionally spread through the use of live bait.

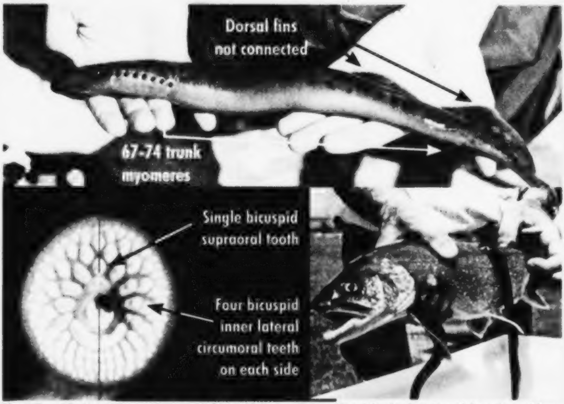
IMPACTS: Invasive ruffe can reach very high densities in short periods of time[8], suggesting the potential of significant impacts upon other species. It may compete for zooplankton and benthic insects with native game and forage fishes. Direct predation on eggs and larvae may also impact other fish species[4,8].

PETROMYZONTIDAE / Lamprey Family

Sea Lamprey

Petromyzon marinus

Other common names: Great sea lamprey, landlocked sea lamprey, lake lamprey, lamprey eel



Photos: Top - John Lyons, Wisconsin Department of Natural Resources; Bottom - Great Lakes Sea Grant Network Exotic Species Library

DESCRIPTION: Body: long and flexible, nearly cylindrical to the dorsal fin where it becomes more laterally compressed; 67-74 trunk myomeres (counted from the last branchial pore to the anterior edge of the vent slit); total length 305-460 mm (up to 762 mm). **Mouth:** a sucking disc, as wide, or wider in diameter than the branchial region; buccal funnel filled with hard, hooked, sharp teeth, radiating in series from the centre; supraoral teeth reduced to a large, single, median bicuspid tooth; inner lateral circumoral teeth bicuspid, a row of four on each side. **Fins:** two dorsal fins separate; second dorsal connected to a broadly pointed caudal fin; without paired or anal fins. **Scales:** none; skin smooth and leathery. **Colour:** variable, newly transformed adults (total length 135-175 mm) grey blue above blending to violet on sides to silver-white below; in larger adult, body and first dorsal with dark blotches; breeding adult olive to orange above and on sides.[1,2,3,4,5]

SIMILAR SPECIES: Silver lamprey (*Ichthyomyzon unicuspis*), chestnut lamprey (*I. castaneus*) and northern brook lamprey (*I. fossor*) have a single dorsal fin with a notch. Although the teeth of silver lamprey are similar to those of sea lamprey, the silver lamprey has unicuspid inner lateral circumoral teeth. Northern brook lamprey and American brook lamprey (*Lampetra appendix*) are smaller (total length <205 mm) than mature sea lamprey and have an oral disk that is not as wide as the branchial region, and contains fewer, more blunt teeth[1,4,5]. Immature individuals (ammocoetes) of *Ichthyomyzon* spp. can be distinguished from those of the sea lamprey by having a single notched dorsal fin and <62 trunk myomeres. Ammocoetes of American brook lamprey can be distinguished from those of sea lamprey by an absence of pigment on the upper lip and suborbital and branchial regions[2].

HABITAT: Immature sea lampreys (ammocoetes) are most common in the silty bottoms of rivers, streams, and sometimes lakes. Adults in landlocked populations feed in open waters of large rivers and lakes[1,3].

INTRODUCED RANGE: In Ontario, the introduced range includes the Great Lakes and associated channels and rivers upstream from Niagara Falls[3,6].

NATIVE RANGE: In Ontario, the native range is limited to Lake Ontario and the St. Lawrence River[7]. In eastern North America, from the Gulf of St. Lawrence and the Atlantic coast from Labrador to the Gulf of Mexico. Also along the Atlantic coast of Europe and the Mediterranean Sea[1].

PATHWAY OF INTRODUCTION AND SPREAD: Sea lamprey colonized Lake Erie from Lake Ontario following improvements made to the Welland Canal in 1919. Population growth and dispersal led to the spread of this species through the remaining Great Lakes[7].

IMPACTS: The parasitic feeding of sea lamprey weakens and most often kills its fish host. While sea lamprey preys upon a wide range of fishes, the invasive populations played a significant role in decimating native stocks of lake trout (*Salvelinus namaycush*), whitefish (*Coregonus clupeaformis*) and walleye (*Sander vitreus*). The reduction in stocks of large predatory fishes triggered a cascade of effects through the associated food web[8]. Some fish stocks have recovered as a result of costly and ongoing sea lamprey control programs[8]. With respect to the Lake Ontario population, the absence of records of its occurrence prior to 1835 suggests that it acquired the role of significant apex predator, necessitating control, in the last century[9].

POECILIIDAE / Livebearer Family

Eastern Mosquitofish *Gambusia holbrooki*

Western Mosquitofish *Gambusia affinis*

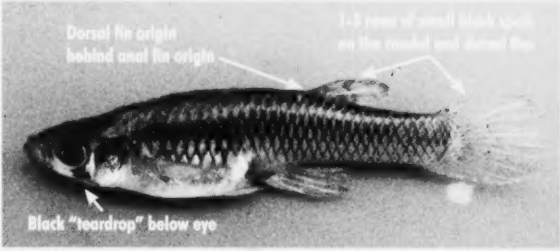

Dorsal fin origin
behind anal fin origin
1-3 rows of small black spots
on the caudal and dorsal fins
Black "teardrop" below eye

Photo: [*Gambusia affinis*, female] John Lyons, Wisconsin Department of Natural Resources

DESCRIPTION: Body: elongate and somewhat compressed; females grow much larger than males and when pregnant show a distended abdomen, total length 22-55 mm (up to 65 mm). **Mouth:** small, supraterminal. **Fins:** single dorsal fin with 6-7 soft rays, originating behind origin of the anal fin; anal fin of male modified to form the gonopodium, a long rod-like structure. **Scales:** 26-32 along the midline (without a lateral line). **Colour:** olive-grey to yellow-brown above, yellow and blue iridescence on silver-grey sides; sometimes with a darker midlateral stripe; black spot beneath eye; black anal spot on pregnant female; 1-3 rows of black spots on pale dorsal and anal fins; dark scale outline gives an overall cross-hatched appearance.[1,2,3,4]

SIMILAR SPECIES: The banded killifish (*Fundulus diaphaneus*) and the central mudminnow (*Umbra limi*), both native to Ontario, have a dorsal fin origin ahead of the anal fin origin and more than 33 scales in lateral series[3]. Once considered subspecies of *Gambusia affinis*, the eastern and western mosquitofish are now recognized as species on the basis of differences in the chromosomes and the structure of the gonopodium[5].

HABITAT: Shallow areas in streams, ponds and ditches, with and without vegetation. The mosquitofish can tolerate low levels of dissolved oxygen and high temperatures[2]. It may thrive in degraded and artificial habitats[6].

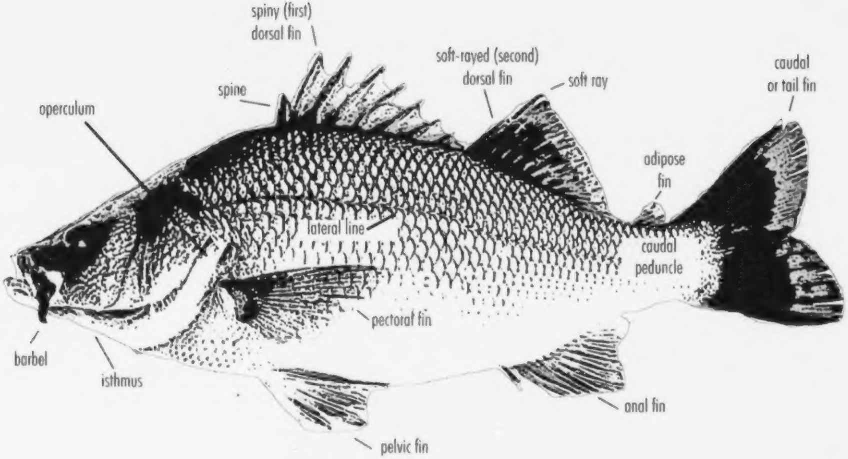
INTRODUCED RANGE: The mosquitofishes are not yet known from the wild in Ontario. In the United States, they are established widely in the west, midwest and northeast, including several states bordering the Great Lakes[7,8]. Established on all continents except Antarctica[6].

NATIVE RANGE: The eastern mosquitofish is found in the eastern United States in Atlantic and Gulf of Mexico slope drainages, west through Alabama. The western mosquitofish is native to watersheds draining into the Gulf of Mexico, from Alabama through Texas, including much of the Mississippi River drainage as far north as Indiana and Illinois[1,5].

PATHWAY OF INTRODUCTION AND SPREAD: Intentionally introduced in other parts of the world as an agent of mosquito control; subsequent spread resulted through population growth and dispersal[6,7,8]. The aquarium and ornamental pond industries are potential vectors of accidental or unlawful release into open waters, particularly given ongoing public concern about mosquito-borne disease.

IMPACTS: As opportunistic predators, mosquitofish readily consume zooplankton and the eggs and larvae of other aquatic vertebrates[9]. This has lead to the extirpation or reduction of populations of amphibians and other fishes[6,10], as well as changes to food web structure and water chemistry[6,9]. The Invasive Species Specialist Group of the IUCN Species Survival Commission designated the mosquitofishes as being among the world's worst invasive species[11,12].

Fish Anatomy



(Image: Michael Butler, Trent University)

3.0 REPORTING PROCEDURE

Collect A Specimen & Record Information

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Report The Sighting

Your assistance with this process, when you encounter a species new to Ontario or an AIS already present but in a new waterbody, is an important step in managing invading species.

3.1 Collecting A Specimen

3.1.1 Algae

The simplest method to obtain algae for identification involves placing a sample of the algae in a sealable container with water and immediately refrigerating it until it can be brought to an expert for identification. A refrigerated specimen is only viable, for identification purposes, up to about 48 hours. See Method A in the table below for further details.

A different method involves adding to samples a preservative compound which preserves them for a couple of months. Methods B and C describe relatively easy applications with Lugol's preservative (iodine-based) or 70% ethanol. More information on these methods and other preservatives can be found in Stein (1973).

Materials & Methods - ALGAE

A. Refrigeration

• Container with lid • Water	(1) Place a small clump of algae inside the container; if it is attached to substrate, scrape algae from surface into the container. (2) Fill about 3/4 of the container with water (3) Seal lid to prevent spillage (4) Label (date, location, species, contact) (5) Refrigerate as soon as possible and keep cold until ready to submit

Materials & Methods - ALGAE

B. Lugol's preservative

• Container with lid • Water • Lugol's preservative	(1) Place a small clump of algae inside the container; if it is attached to substrate, scrape algae from surface into the container. (2) Place about 5-10 ml of water in container (3) Add enough drops of Lugol's to turn the water a strong tea colour (4) Seal lid to prevent spillage (5) Label (date, location, species, contact) (6) Store away from heat and direct sunlight

C. Ethanol

• Container with lid • 70% ethanol	(1) Place a small clump of algae inside the container; if it is attached to substrate, scrape algae from surface into the container. (2) Fill about 3/4 of the container with 70% ethanol (3) Seal lid to prevent spillage (4) Label (date, location, species, contact) (5) Store away from heat and direct sunlight

Notes: Water can be taken from the collection site or tap water. A small glass or plastic container, no more than 250 ml in size, is typically sufficient. Lugol's is usually applied to stain and preserve specimens for algal counts. Ethanol is a common preservative, but is not ideal for soft-celled algal species that may be in the sample.

References:

Kirkwood, A. 2007. University of Calgary. Personal communication.

Stein, J.R. 1973. Handbook of Phycological Methods. University Press, Cambridge, England.

University of Wisconsin. 2007. Madison Botany 330 Algae Webpage, Preservation of Algal Samples. Available from http://www.botany.wisc.edu/courses/botany_330/preservation.html / [accessed August 2007].

3.1.2 Plants

Aquatic plants may be collected in two ways. The simplest method is to place the plant in a watertight bag, along with a sufficient quantity of water to keep it wet. The bag should be stored in a refrigerator, no longer than a week, until it can be brought to an expert for identification. If transporting the specimen via post or courier, the bag can be placed within a second bag to further reduce the risk of leakage. Additional protection can be afforded by placing the bags within an airtight container, such as a plastic jar. Further details can be found in Methods A and B in the following table.

The preferred method for collecting plant specimens is to press them using a plant press. This method produces a museum-quality specimen which is the best way to document an occurrence of an introduced species. Instructions for pressing robust aquatic plants are presented in Method C below. For finely-leaved species such as *Cabomba, Myriophyllum* and some *Potamogeton*, which tend to clump together into an undistinguishable mass when removed from water, follow the instructions in Method D where water is used to "float" out the plant onto waxed paper prior to pressing. This way, the plant features which are needed to confirm identification are easily visible.

For details on more effective plant presses for routine collections or longer-term storage, see the references at the end of this section.

Important! For all plant specimens, attempt to collect the entire plant, including fruits, flowers, stem, leaves, roots, and other vegetative organs like rhizomes or stolons. Rinse or shake away any excess soil on site. It is recommended to press and dry plants as soon after collecting them as possible. While collecting plants, avoid breaking them into fragments or allowing fruit or seeds to break free and fall. If it cannot be avoided, dispose of this material in the garbage so that fragments, fruit and seed are not spread to new areas where they can often produce more plants.

Materials & Methods - PLANTS

A. Refrigeration

• Container with lid • Water	(1) Fill about half of the container with water (2) Place plant inside container (3) Seal lid to prevent spillage (4) Label (date, location, species, contact) (5) Keep specimen refrigerated until ready to submit

B. Refrigeration

• Plastic bags • Water • Paper towel	(1) Soak paper towel with water (2) Place wet paper towel in bag with enough water to line bottom of bag (3.a) Place entire plant inside bag, or (3.b) For larger plants, place underwater or underground portion of plant (roots, rhizomes) in the bag and tighten around stem to keep moisture in (4) If fruit or seed are falling off, cover this portion with another plastic bag (5) Close bag(s) full with air, which helps cushion and protect contents (6) Label (date, location, species, contact) (7) Keep specimen refrigerated until ready to submit

Notes: Water can be taken from the collection site or tap water. Size of container or bag needed depends on size or amount of plant collected. A 500 ml container or a freezer-size, watertight bag are generally sufficient but grocery-size or larger bags may be more appropriate.

C. Pressing plants

• Paper towel • Newspaper • Corrugated cardboard (about same size as folded newspaper) • Ribbon or straps, or some weight to press plant flat	(1) Gently dry wet plant with paper towel (2) On top of corrugated cardboard, place a layer of folded newspaper (3) Lay plant on folded newspaper - spread plant parts so there is minimum overlap between parts - The stem can be folded zig-zag-like to fit, if needed - Display the underside of at least one leaf - Press open flowers to display the inside - Place any loose seed and fruit into a small paper packet/envelope

C. Pressing plants *continued*

• Small paper packets or envelopes • *(preferable but optional) Thick blotting paper, felt, or thin foam sheets used in carpet underpadding*	(4) Cover plant with a layer of newspaper, then another piece of cardboard (5) Tie ribbon or straps around layers of cardboard and newspaper to fasten pieces together so contents stay in place (6) A weight of some form (e.g., book) may also be placed on top to help flatten and secure contents (7) Label (date, location, species, contact) (8) Store in a well ventilated, dry and warm area (9) If newspaper is damp after first 24 hours, replace it with dry newspaper and store as described in (8). *If using blotting paper/felt/foam, place a sheet of this material between the cardboard and newspaper on each side of the specimen.*

D. Pressing plants

• Same as in Method C, plus wax paper (sufficient amount to fold and cover the bottom and top of plant)	(1) Float plants in water (at site or in a sink) (2) Place a sheet of wax paper under the plant in the water (3) Raise the sheet horizontally and let the plant catch or stick on the paper (4) Slowly tilt the sheet, in which the plant now lays, and remove them from the water (5) Follow steps in Method C above. In step C.3, rather than transferring the plant from wax paper to newspaper, place the wax paper, with the plant, onto the folded newspaper and cover plant with wax paper.

Notes: The cardboard, newspaper and blotting paper/felt/foam help the drying process. The latter material also helps press thicker plant pieces as it cushions or takes the shape of its contents.

References:

Bowles, J.M. 1996. Guide to plant collection & identification. University of Toronto, Toronto. Available from http://www.botany.utoronto.ca/courses/BOT307/B_How/janecoll.html [accessed July 2007].

Savile, D.B.O. 1962. Collection and care of botanical specimens. Canada Department of Agriculture, Research Branch, Publication 113. Ottawa, Ontario.

3.1.3 Invertebrates

Collecting specimens of aquatic invertebrates may involve preserving them in alcohol, air drying or freezing them. These relatively simple methods are described in the table below. Instructions for alcohol preservation are presented in Method A; for very small organisms like waterfleas or zebra mussel veligers, apply Method B with alcohol. Directions to prepare dried specimens of molluscs, snails, clams, or crayfish smaller than about 4 cm in length (larger specimens may spoil before drying) are presented in Method C. These methods are preferred for identification purposes and for longer-term storage as voucher specimens. If they cannot be applied, freezing larger specimens will suffice for the immediate need of identification and is described in Method D.

It is recommended that these directions be preceded by cleaning of specimens (removing dirt from shells, etc.) and followed as soon after collecting organisms as possible. Live invertebrates kept in cool water usually die within one day of collection and start to spoil on the second day. If organisms are alive, particularly larger-bodied organisms (snail or crayfish-sized), euthanize them humanely (University of Alberta 2007 and Cordeiro and Bowers-Altman 2007 provide some options) before preserving them, i.e., prior to placing them in alcohol or drying.

Materials & Methods - INVERTEBRATES	
A. Alcohol preservation	
• Container with lid • 70-80% ethanol or isopropyl alcohol (rubbing alcohol)	(1) Fill most of container with alcohol (more than enough to cover specimens fully) (2) Place specimen inside container (3) Seal lid to prevent spillage (4) Label (date, location, species, contact) (5) Store away from direct sunlight and heat (6) If alcohol appears cloudy after a few days, replace all but an inch from container bottom with fresh alcohol.
B. Alcohol preservation	
• Same as in Method A	(1) Collect up to 1/3 of container with a water sample containing small organisms (2) Add 2x or more that amount of alcohol to the sample (2 parts alcohol: 1 part sample) (3) Seal lid to prevent spillage

Materials & Methods - INVERTEBRATES

B. Alcohol preservation *continued*

	(4) Label (date, location, species, contact) (5) Store away from direct sunlight and heat

C. Air drying

• Newspaper or a flat pan • Container with lid • Cotton balls or tissue	(1) Lay specimen on newspaper or flat pan (2) Air dry at 20-28°C for 3 to 4 days (3) Place completely dried specimen in container with cotton ball or tissue, which helps secure them in place (4) Seal lid (5) Label (date, location, species, contact) (6) Store in dry area

D. Freezing

• Container with lid • Plastic bag	(1) Place specimen inside plastic bag and seal (2) Place plastic bag, with the specimen, inside a container and close with lid (protects specimen during delivery) (3) Label (date, location, species, contact) (4) Store in freezer until ready to submit

Notes: Size of container needed depends on size or number of specimens collected. A 500 ml container for alcohol preservation or a small plastic vial for dried specimens are generally sufficient.

References:

Clarke, A.H. 1981. The freshwater molluscs of Canada. National Museum of Canada, Ottawa. Pp. 12-16.

Cordeiro, J. and J. Bowers-Altman. 2007. Freshwater mussels of the New York Metropolitan Region and New Jersey. Center for Biodiversity and Conservation at the American Museum of Natural History, New York. Available from http://cbc.amnh.org/mussel/ [accessed September 2007].

Crocker, D.W. and D.W. Barr. 1971. Handbook of the crayfishes of Ontario. University of Toronto Press, Toronto. Pp. 137-138.

Dermott, R. 2007. Fisheries and Oceans Canada. Personal communication.

Ontario Federation of Anglers and Hunters. Invading Species Watch Program: an instruction manual for volunteers. Available from www.invadingspecies.com/downloads/pdf/WatchManual2006.pdf#Zoom=90% [accessed July 2007].

University of Alberta. 2007. Freshwater invertebrate diversity: Zoology 351. Available from www.biology.ualberta.ca/courses.hp/zool351/general.htm [accessed September 2007].

3.1.4 Fishes

The discovery of an invasive fish species can be significant depending on the species and the location of capture. Even in cases where a competent biologist identifies the fish, properly collected voucher specimens allow for verification if identification is called into question. When you encounter a fish you wish to report, it is recommended that digital photos of the fish are taken and the fish be refrigerated, as described below in Methods A & B. Maintain the fish whole - do not gut, dissect, collect tissue or otherwise cut the fish - this step ensures that key morphological features needed for identification remain intact. It is important not to preserve or freeze the fish to ensure integrity of the specimen is maintained, which will enable confirmation of identification and various analyses including ploidy testing, DNA sequencing, morphological analyses, etc. The exception is for suspected invasive carp species that, in the case where there is no other way to prevent the fish from spoiling, it can be frozen as described in Method C. In this situation, extraction of eyeballs for ploidy testing is recommended (see tips under freezing).

Materials & Methods - FISHES	
A. Photograph	
• Camera (preferably digital so images can be sent ASAP) • Computer to download photos to send via email	(1) Photograph whole fish with a ruler or other object so that the relative size of the fish is evident (2) Photograph significant external features (e.g., pelvic fin of the Round Goby, the tubular nostrils of the Tubenose Goby, the ventral keel of the Rudd)
B. Refrigeration	
• Plastic bags • Refrigerator or cooler with ice	(1) Double bag the whole fish in plastic bags or other suitable container that will surround the entire fish and minimize abrasion and damage to body and fins, or drying out of the specimen (2) Place label with date, location, species and contact information for collector in bag

B. Refrigeration *continued*

	(3) Gently force as much air as possible from the bag, seal and place in the fridge (4) If refrigeration is not an option, place the bagged specimen in a cooler or some other suitable container with ice to keep cool, and store away from heat and direct sunlight.

C. Freezing

• Plastic bags • Freezer	(1) Only freeze the fish if there is no other way to keep it from spoiling (2) Place the whole fish in double plastic bags or other suitable container that will surround the entire fish and minimize abrasion and damage to body and fins, or drying out the specimen (3) Place label with date, location, species, and contact information for collector in the bag (4) Gently force as much air as possible from the bag, seal and place the plastic bag in the freezer

Notes: In the case of invasive carp specimens (bighead, black, silver and grass carps), if the only option to prevent the fish from spoiling is to freeze it, collect the eyeballs before freezing the fish. Take care to excise eyeballs whole, place in plastic bag, gently force air out of bag, seal, put in a sturdy container and keep refrigerated or on ice – Do Not Freeze Eyeballs – it is important that eyeballs do not dry out or get crushed.

References:

Chapman, D. 2008. United States Geological Survey. Columbia, Missouri. Personal communication.

Cudmore, B. 2008. Fisheries and Oceans Canada. Burlington, Ontario. Personal communication.

Holm, E. 2008. Department of Natural History, Royal Ontario Museum. Toronto, Ontario. Personal communication.

3.2 Recording Information

Important details to document and submit are listed here. Items with asterisks * are the most significant pieces of information to document if not all details can be recorded. ***Digital photos*** (e.g., extent of the occurrence, specimen close-ups showing key ID features) are extremely helpful and can be emailed to invading_species@ofah.org.

Contact name*	**Affiliation***
Phone number*	**Email***
Date of observation* yyyy/mm/dd	**Species scientific name*, common name**
Waterbody name*	**County***
Township*	**Datum*** Record the Datum being used with your GPS (NAD 83 preferred)
DDLatitude*, DDLongitude* In decimal degrees (DD); include at least 5 decimal places. E.g., 44.10016, -78.29386.	
Or - **UTM*** Although latitude/longitude are preferred, if providing UTM coordinates, include UTM Zone, Easting and Northing. E.g., Zone 17, 716599 E, 4886588 N.	
Source of coordinates* E.g., paper map, GPS, electronic or online maps and software, other (explain).	
Directions* Use stable landmarks or reference points (intersections, nearest town, etc.) which will remain long after the observation. E.g., East of the town of Bewdley, on South shore of Rice Lake, 250 metres East from Bamsey Dr. and Oak Hills Rd. intersection.	
Description of occurrence* Describe the habitat, number of individuals or size of occurrence, etc. E.g., in 20 x 50 metre shallow marsh, with approximately 10 flowering individuals.	
Other noteworthy information	

References:

Chapman, A.D. and J. Wieczorek (eds). 2006. Guide to best practices for georeferencing. Copenhagen: Global Biodiversity Information Facility.

Ontario Federation of Anglers and Hunters and Ontario Ministry of Natural Resources. 2007. InvadingSpecies.com Report a sighting online form. Available from www.invadingspecies.com/Report.cfm [accessed July 2007].

3.3 Report The Sighting

Any occurrence of species new to Ontario or AIS already present but in a new area, whether they are included in the field guide or not, is important to ***report to*** the

Invading Species Hotline (1-800-563-7711) or

website (www.invadingspecies.com).

Once you submit information on the sighting via the hotline or website, program staff will contact you (or whomever was given as the contact) to clarify any details and discuss where the specimen you collected should go to confirm identification. This confirmation is done by a taxonomist/expert which might be, for example, at the local OMNR District Office, a university or museum. If you cannot bring the specimen to the appropriate location, alternative arrangements can be made for it to be picked-up, couriered or mailed.

CYMBELLACEAE

Didymo

Didymosphenia geminata

1. MDDEP-MRNF Scientific Advisory Committee on *Didymosphenia geminata*. 2007. What is didymo and how can we prevent it from spreading in our rivers? Québec, ministère du Développement durable, de l'Environnement et des Parcs et ministère des Ressources naturelles et de la Faune. ISBN: 978-2-550-49391-4 (PDF).
2. Spaulding, S. and L. Elwell. 2007. Increase in nuisance blooms and geographic expansion of the freshwater diatom *Didymosphenia geminata*: recommendations for response. United States Environmental Protection Agency and Federation of FlyFishers, United States.
3. Kirkwood, A. 2007. University of Calgary. Personal communication.
4. Wehr, J.D. and R.G. Sheath. 2003. Freshwater algae of North America: ecology and classification. Academic Press, San Diego, USA.
5. Kilroy, C. 2004. A new alien diatom, *Didymosphenia geminata* (Lyngbye) Schmidt: its biology, distribution, effects and potential risks for New Zealand fresh waters. National Institute of Water and Atmospheric Research, New Zealand. Client Report: CHC2004-128. Available from www.biosecurity.govt.nz/pests-diseases/plants/didymo/didyo-schmidt-report.pdf [accessed December 2006].

ARACEAE / Arum Family

Water Lettuce

Pistia stratiotes

1. Thompson, S.A. 2000. Araceae. *In* Flora of North America North of Mexico, Volume 22: Magnoliophyta: Alismatidae, Arecidae, Commelinidae (in part), and Zingiberidae: Araceae. *Edited by* Flora of North America Editorial Committee. Oxford University Press, New York. Pp. 128-142.
2. Dray, F.A. Jr. and T.D. Center. 2002. Waterlettuce. *In* Biological control of invasive plants in the Eastern United States. *Edited by* R. Van Driesche, S. Lyon, B. Blossey, M. Hoddle, and R. Reardon. USDA Forest Service Publication FHTET-2002-04 [online]. Available from www.invasive.org/eastern/biocontrol/5Waterlettuce.html [accessed January 2007].
3. Darbyshire, S.J. 2002. Ephemeral occurrence of the Mosquito Fern, *Azolla caroliniana,* at Ottawa, Ontario. Canadian Field-Naturalist 116:441-445.
4. Ontario Federation of Anglers and Hunters and Ontario Ministry of Natural Resources. 2007. Aquatic invasive species database – distribution obtained from C. Proctor in April 2007.
5. Cochran, P.A., S. Pociask, H. Warthesen, and N. Proulx. 2006. Noteworthy collection: Minnesota. *Pistia stratiodes* L. (Araceae). Waterlettuce. The Michigan Botanist 45: 210-213.
6. Stoddard, A.A. 1989. The phytogeography and paleofloristics of *Pistia stratiotes* L. Aquatics 11: 21-24.
7. Rivers, L. 2002. Water lettuce, *Pistia stratiotes* [online]. Available from http://www.iisgcp.org/EXOTICSP/waterlettuce.htm [accessed November 2006].
8. Attionu, R. H. 1976. Some effects of water lettuce (*Pistia stratiotes,* L.) on its habitat. Hydrobiologia 50: 245-254.

AZOLLACEAE / Floating Fern Family

Mosquito Fern

Azolla pinnata

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BUTOMACEAE / Flowering Rush Family

Flowering Rush

Butomus umbellatus

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CABOMBACEAE / Water-Shield Family

Fanwort

Cabomba caroliniana

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HALORAGACEAE / Water-Milfoil Family

Eurasian Water-Milfoil

Myriophyllum spicatum

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CYPERACEAE / Sedge Family

European Lake Sedge

Carex acutiformis

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HALORAGACEAE / Water-Milfoil Family

Parrotfeather

Myriophyllum aquaticum

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HYDROCHARITACEAE / Frog-Bit Family

Brazilian Waterweed

Egeria densa

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HYDROCHARITACEAE / Frog-Bit Family

European Frog-Bit

Hydrocharis morsus-ranae

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HYDROCHARITACEAE / Frog-Bit Family

Hydrilla

Hydrilla verticillata

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IRIDACEAE / Iris Family

Yellow Iris

Iris pseudacorus

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LYTHRACEAE / Loosestrife Family

Purple Loosestrife

Lythrum salicaria

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MENYANTHACEAE / Buckbean Family

Yellow Floating Heart

Nymphoides peltata

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POACEAE / Grass Family

European Common Reed

Phragmites australis subsp. *australis*

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PONTEDERIACEAE / Pickerel-Weed Family

Water Hyacinth

Eichhornia crassipes

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POTAMOGETONACEAE / Pondweed Family

Curly-Leaved Pondweed

Potamogeton crispus

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SALVINIACEAE / Floating Fern Family

Watermoss - *Salvinia* spp.

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TRAPACEAE / Water-Chestnut Family

European Water Chestnut

Trapa natans

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AMPULLARIIDAE / Apple Snail Family

Channeled Apple Snail

Pomacea canaliculata

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CAMBARIDAE / Crayfish Family

Rusty Crayfish

Orconectes rusticus

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Spiny Waterflea

Bythotrephes longimanus

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CERCOPAGIDAE / Waterflea Family

Fishhook Waterflea

Cercopagis pengoi

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CORBICULIDAE / Little Basket Clam Family

Asian Clam

Corbicula fluminea

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DREISSENIDAE / Dreissenid Mussel Family

Quagga Mussel

Dreissena bugensis

1. Mackie, G.L. 2000. Ballast water introductions of Mollusca. *In* Nonindigenous freshwater organisms: vectors, biology, and impacts. *Edited by* R. Claudi and J.H. Leach. CRC Press LLC, Florida. Pp. 219-254.

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DREISSENIDAE / Dreissenid Mussel Family

Zebra Mussel

Dreissena polymorpha

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Zebra Mussel *continued*

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Gammarid

Echinogammarus ischnus

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HYDROBIIDAE / Spire Snail (or Mud Snail) Family

New Zealand Mud Snail

Potamopyrgus antipodarum

1. Pennak, R.W. 1953. Fresh-water invertebrates of the United States. The Ronald Press Company, New York.

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MYSIDAE / Opossum Shrimp Family

Red Mysid

Hemimysis anomala

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Red Mysid *continued*

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VIVIPARIDAE / Mysterysnail Family

Chinese Mysterysnail

Cipangopaludina chinensis

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VIVIPARIDAE / Mysterysnail Family

Banded Mysterysnail

Viviparus georgianus

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CYPRINIDAE / Minnow and Carp Family

Goldfish

Carassius auratus

1. Scott, W.B. and E.J. Crossman. 1973. Freshwater fishes of Canada. Fisheries Research Board of Canada Bulletin 184.
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CYPRINIDAE / Minnow and Carp Family

Grass Carp

Ctenopharyngodon idella

1. Jenkins, R. E. and N. M. Burkhead. 1994. Freshwater fishes of Virginia. American Fisheries Society, Bethesda.
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Common Carp

Cyprinus carpio

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Silver Carp

Hypophthalmichthys molitrix

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Silver Carp *continued*

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CYPRINIDAE / Minnow and Carp Family

Bighead Carp

Hypophthalmichthys nobilis

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CYPRINIDAE / Minnow and Carp Family

Black Carp

Mylopharyngodon piceus

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CYPRINIDAE / Minnow and Carp Family

Rudd

Scardinus erythropthalmus

1. Page, L.M. and B.M. Burr. 1991. A field guide to freshwater fishes of North America north of Mexico. Houghton Mifflin Company. Boston.
2. Crossman, E.J., E. Holm, R. Cholmondeley, and K. Tuininga. 1992. First record for Canada of the rudd, *Scardinius erythropthalmus*, and notes on the introduced round goby, *Neogobius melanostomus*. Canadian Field-Naturalist 106:206-209.

Rudd *continued*

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CYPRINIDAE / Minnow and Carp Family

Tench

Tinca tinca

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3. Schofield, P.J., J.D. Williams, L.G. Nico, P. Fuller, and M.R. Thomas. 2005. Foreign nonindigenous carps and minnows (Cyprinidae) in the United States - a guide to their identification, distribution, and biology. U.S. Geological Survey Scientific Investigations Report 2005-5041.

Tench *continued*

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GASTEROSTEIDAE / Stickleback Family

Fourspine Stickleback

Apeltes quadracus

1. Scott, W.B. and E.J. Crossman. 1973. Freshwater fishes of Canada. Fisheries Research Board of Canada Bulletin 184.
2. Smith, C.L. 1985. Inland fishes of New York State. New York State Department of Environmental Conservation, Albany.
3. Scott, W.B. and M.G. Scott. 1988. Atlantic fishes of Canada. Canadian Bulletin of Fisheries and Aquatic Sciences 219.
4. Page, L.M. and B.M. Burr. 1991. A field guide to freshwater fishes of North America north of Mexico. Houghton Mifflin Company, Boston.
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6. Hubbs, C.L. and K.F. Lagler. 2004. Fishes of the Great Lakes region (Revised by G. R. Smith). The University of Michigan Press, Ann Arbor.

Fourspine Stickleback *continued*

7. Stephenson, S.A. and W.T. Momot. 2000. Threespine, *Gasterosteus aculeatus*, and fourspine, *Apeltes quadracus*, sticklebacks in the Lake Superior basin. Canadian Field-Naturalist 114: 211-216.
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GASTEROSTEIDAE / Stickleback Family

Threespine Stickleback

Gasterosteus aculeatus

1. Scott, W.B. and E.J. Crossman. 1973. Freshwater fishes of Canada. Fisheries Research Board of Canada Bulletin 184.
2. Smith, C.L. 1985. Inland fishes of New York State. New York State Department of Environmental Conservation, Albany.
3. Page, L.M. and B.M. Burr. 1991. A field guide to freshwater fishes of North America north of Mexico. Houghton Mifflin Company, Boston.
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GOBIIDAE / Goby Family

Round Goby

Neogobius melanostomus

1. Crossman, E.J., E. Holm, R. Cholmondeley, and K. Tuininga. 1992. First record for Canada of the rudd, *Scardinius erythrophthalmus*, and notes on the introduced round goby, *Neogobius melanostomus*. Canadian Field-Naturalist 106: 206-209.
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GOBIIDAE / Goby Family

Tubenose Goby

Proterorhinus marmoratus

1. Berg, L.S. 1949. Freshwater fishes of the U.S.S.R. and adjacent countries, 4th edition. [Translated from Russian, 1962-1965, for the Smithsonian Institution and the National Science Foundation, by Israel Program for Scientific Translations, Jerusalem, Israel].

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9. Corkum, L. 2007. Department of Biological Sciences, University of Windsor. Personal communication.

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MORONIDAE / Striped Bass Family

White Perch

Morone americana

1. Scott, W.B. and E.J. Crossman. 1973. Freshwater fishes of Canada. Fisheries Research Board of Canada Bulletin 184.
2. Page, L.M. and B.M. Burr. 1991. A field guide to freshwater fishes of North America north of Mexico. Houghton Mifflin Company, Boston.
3. Hubbs, C.L. and K.F. Lagler. 2004. Fishes of the Great Lakes region (revised edition: revised by G. R. Smith). The University of Michigan Press, Ann Arbor.
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OSMERIDAE / Smelt Family

Rainbow Smelt

Osmerus mordax

1. Scott, W.B. and E.J. Crossman. 1973. Freshwater fishes of Canada. Fisheries Research Board of Canada Bulletin 184.
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PERCIDAE / Perch Family

Ruffe

Gymnocephalus cernuus

1. Page, L.M. and B.M. Burr, 1991. A field guide to freshwater fishes of North America north of Mexico. Houghton Mifflin Company, Boston.
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PETROMYZONTIDAE / Lamprey Family

Sea Lamprey

Petromyzon marinus

1. Scott, W.B. and E.J. Crossman. 1973. Freshwater fishes of Canada. Fisheries Research Board of Canada Bulletin 184.
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Sea Lamprey *continued*

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POECILIIDAE / Livebearer Family

Eastern Mosquitofish *Gambusia holbrooki*

Western Mosquitofish *Gambusia affinis*

1. Page, L.M. and B.M. Burr. 1991. A field guide to freshwater fishes of North America north of Mexico. Houghton Mifflin Company, Boston.
2. Jenkins, R.E. and N.M. Burkhead. 1993. Freshwater fishes of Virginia. American Fisheries Society, Bathesda.
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Mosquitofish *continued*

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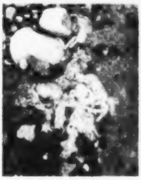
Field Guide to Aquatic Invasive Species - Photo Index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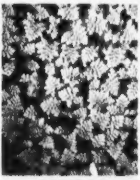
Ara-pis-str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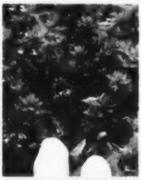
But-but-umb

Cab-cab-car

Cyp-car-acu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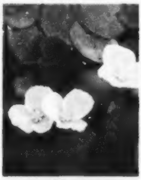
Hal-myr-spi

Hyd-ege-den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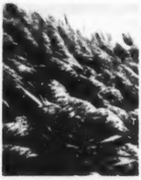
Hyd-hyd-ver

Iri-iri-pse

Lyt-lyt-sal

Men-nym-pel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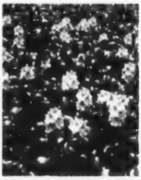
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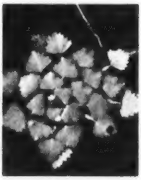
Pot-pot-cri

Sal-sal-spp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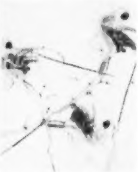
Amp-pom-can

Cam-orc-rus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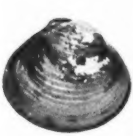
Cer-cer-pen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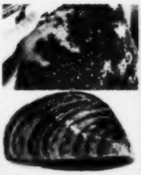
Dre-dre-bug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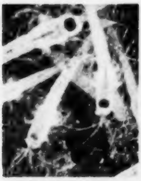
Gam-ech-isc

Hyd-pot-ant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Viv-cip-chi

Viv-viv-geo

Cyp-car-aur

Cyp-cte-ide

Cyp-cyp-car

Cyp-hyp-mol

Cyp-hyp-nob

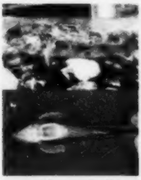
Cyp-myl-pic

Cyp-sca-ery

Cyp-tin-tin

Gas-ape-qua

Gas-gas-acu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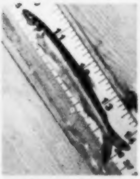
Gob-pro-mar

Mor-mor-ame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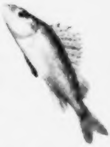
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Pet-pet-mar

Poe-gam-spp

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